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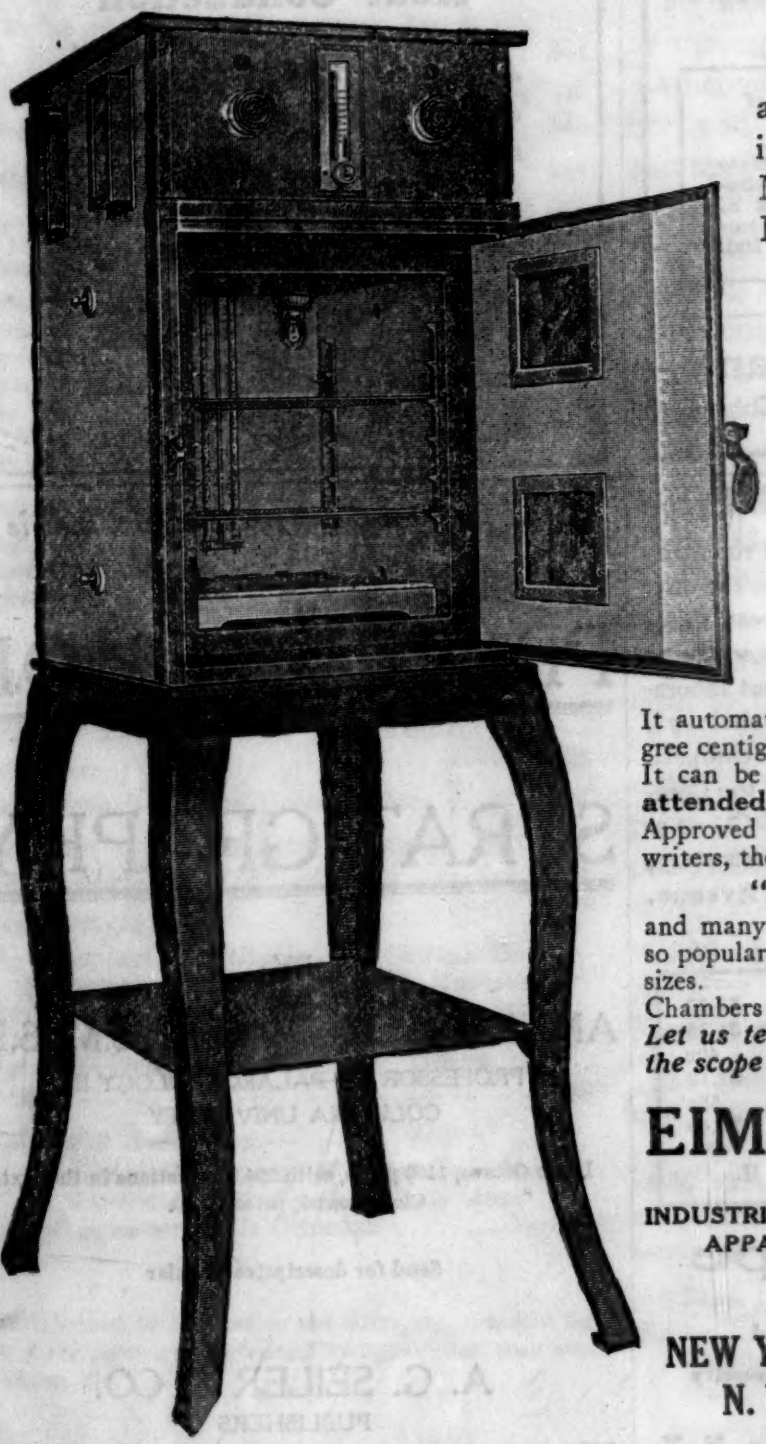

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THE RELATION OF MATHEMATICS TO THE NATURAL SCIENCES[1]

IN considering the relationship of mathematics to the natural sciences, we shall do well to see what mathematics is and what are its methods.

Mathematics has not always been looked at through the same glasses. The field of mathematics to the early workers was number and quantity. Euclid put into his axioms what he considered to be the fundamental facts of the world about him. Diophantus, of Alexandria, a worker in algebra, considered only positive roots of equations. They were dealing with realities and not with abstract matters. Some time later mathematicians tried to prove their axioms—often called self-evident truths—and made a wonderful discovery. That was, that a "self-evident truth" might be replaced by its contrary and the result still be a consistent body of doctrine. And thus the glasses were changed, to be mathematical the conclusions must be the result of the assumptions and these must be consistent. The assumptions need have no physical interpretation, indeed they might contradict any of our theories, but they must not contradict each other. There might be foreign war, but no internal conflict. I like the following of Professor Keyser, of Columbia University:[2]

> He (the mathematician) is not absolutely certain, but he believes profoundly that it is possible to find axioms, sets of a few propositions each, such that the propositions of each set are compatible, that the propositions of such a set imply other propositions, and that the latter can

[1] Read before the Purdue University chapter of Sigma Xi, October 25, 1916.

[2] SCIENCE, Vol. 35 (1912), p. 107.

be deduced from the former with certainty. That is to say, he believes that there are systems of coherent or consistent propositions, and he regards it as his business to discover such systems. Any such system is a branch of mathematics.

A word might be said about pure and applied mathematics. We may have a branch of mathematics with its postulates or axioms consistent and have no physical interpretation of them. On the other hand, we may make our postulates consistent with what we believe to be the proper interpretation of certain phenomena, and this would be applied mathematics. It is to be observed that after we have our conditions once fixed by our interpretation of these phenomena, we proceed to our conclusions in a way which is wholly independent of whether we have the right interpretation or not, and are thus back in the domain of pure mathematics.

The popular conception of mathematics has been that it devoted itself to problem solving. You will see, however, that the mathematician concerns himself not with the solution of particular problems, but with the principles which underlie the solution of classes of problems. There is and has been a lively interest in problem solving as is evidenced by the problem departments of various journals. To some the solution of these problems has offered simply the diversion which comes from the solution of a puzzle, to others they have offered a real mathematical stimulus.

There are two general methods of working—I mean of research—in mathematics, the intuitional and postulational. In the case of the first the worker jumps to his conclusions, as it were, guided by some analogy or by his sense of what the facts should be or by his experience; and then follows this drawing of conclusions by filling in his proof by rigorous deduction. In the second method the postulates are kept definitely in view and results are reached by deduction. Most discoveries are, I think, made by the intuitional method. Most progress can be made by leaping across barriers and viewing the country beyond and then returning to build roads and tunnels. It is true that when we attempt to build the road it may not lead us where we leaped, it may not lead us anywhere, and we must return to our starting point. But we build with so much more enthusiasm, with so much more skill, if we think we know where the road leads. The postulational method of work is more formal and is a better tool for the road building than for spying out the land.

We learned our arithmetic by the intuitional method. We said $1+1=2$, not because of some set of postulates, but because in our experience one and one gave something to which we attached the name two. Now to set down our postulates and prove that $1+1=2$ is possible and profitable at the proper time, but altogether out of place in an elementary arithmetic. In plane geometry we had our introduction to the postulational method. In this subject we started with a set of postulates explicitly stated and deduced from them certain results. In discovering the facts of Euclidean geometry, intuition is largely called upon, while in setting those facts down in a text-book we use the postulational method. Euclidean geometry is so largely intuitional in discovery because its postulates agree with our notions of space. In the non-Euclidean geometries we can not trust our intuition and must depend directly on our postulates.

If instead of saying that the whole is equal to the sum of its parts, we say that a part may equal the whole, our intuition is no safe guide. Other examples might be given.

Research work in mathematics attracts two classes of workers, those interested for

mathematics' sake and those interested in creating a tool with which to attack some other science. The search after truth—geographical, religious, scientific—has always lured men. The desire to create, to build some new thing, is continually finding outlet in invention, in exploration, and in scientific research. That desire which sends some men to the poles of the earth, to the tops of mountains, or to the heart of the desert, sends other men over the mountain tops of geometry, or among the pitfalls of analysis, or through the labyrinth of point sets, to some hitherto untrodden field of mathematics. The mathematician creates an intellectual fabric which is just as real and just as beautiful to him as the tapestry is to the weaver. Some put forth their effort in any field that attracts; others, the utilitarians, choose parts which they think will be fruitful in applications.

Knowledge of pure science precedes its application. The properties of conic sections were well known before Kepler and Newton wanted to use them in their theories of planetary motion. The infinitesimal calculus was developed before and not after it was needed in physics. The differential equation had to be understood before it could be applied. Mathematicians have ready now the integral equation and the difference equation which, I believe, have only made a beginning in their service to science. It may be the man who is not seeking utilitarian ends who discovers the most useful facts. Roentgen was not seeking an aid for the medical profession when he discovered the X-rays. That man who reads carefully the history of scientific discovery and its application will not criticize any worker for choosing a field which is apparently remote from usefulness.

How many are working in mathematics, what have they done and what are they doing? There are some six or eight of the more important mathematical societies in various parts of the world with a total membership of over three thousand. These societies comprise in their membership practically all the research workers, besides many others not so engaged. The Subject Index of the Royal Society of London Catalogue of Scientific Papers, volume 1, which gives practically a complete list of mathematical articles which appeared during the nineteenth century, says in its preface that it contains 38,748 entries referring to articles in 701 serials and has rejected 750 as having no scientific value. G. Valentin, of Berlin, has collected a list of 150,000 titles of books and articles published before the beginning of the twentieth century. The *Jahrbuch über die Fortschritte der Mathematik* is a yearly review and each year publishes a volume of about 1,000 pages with very short reviews of books and of papers published in about 200 serials. A very conservative estimate would be that each year there appear 2,000 articles, in addition to the books which contain no new matter. Professor G. A. Miller, of Illinois University, estimates that there was published during the first fifteen years of the present century about one fifth as much mathematical research as during all time before. Mathematicians have varied greatly in their productivity. At one extremity is Galois, killed in a duel before he was twenty-one years old, whose essential contribution to mathematics requires about sixty pages of print; and at the other are Cauchy, whose works are expected to fill twenty-seven volumes when printed, and Euler, the printing of whose work as planned will fill forty-five large volumes.

Now, what relation can this science which deals with the abstract have to do with the natural sciences which deal with

the concrete? Professor A. Voss, of the University of Munich, said in a lecture in 1908:

> Our entire present civilization, as far as it depends upon the intellectual penetration and utilization of nature, has its real foundation in the mathematical sciences.

You will observe that he does not say in mathematics, but in the sciences which have made use of mathematics in their development. Let us investigate this a little. Can you realize what would happen, just what stage of civilization we should be in, if all that is developed by the use of mathematics could be removed from the world by some magic gesture? Every branch of physics makes use of mathematics; chemistry is not free from it; engineering is based upon its developments; sociology, economics and variation in biology make use of statistics and probability. Our skyscrapers must disappear; our great bridges and tunnels must be removed; our transportation systems, our banking systems, our whole civilization, indeed, must step backward many centuries.

Mathematics and its symbolism appear in rather unexpected places. S. G. Barton,[3] of the Flower Observatory, University of Pennsylvania, says that in the Encyclopædia Britannica, written not for the specialist so much as for the general reader, there are one hundred four articles which make use of the notation of the infinitesimal calculus, of which only about one fourth are pure mathematics. You may be surprised to know that you need the infinitesimal calculus to read the articles on clock, heat, lubrication, map, power transmission, ship building, sky, steam engine and strength of materials.

Take these sentences from Simon Newcomb's article in the Encyclopædia Britannica on celestial mechanics:

> The purpose of the present article is to convey a general idea of the methods by which the results of celestial mechanics are reached, without entering into those technical details which can be followed only by a trained mathematician. It must be admitted that any intelligent comprehension of the subject requires at least a grasp of the fundamental conceptions of analytical geometry and the infinitesimal calculus, such as only one with some training in these subjects can be expected to have. . . . The non-mathematical reader may possibly be able to gain some general idea, though vague, of the significance of the subject.

Sir John Herschel in his introduction to his book, "Outlines of Astronomy," says:

> Admission to its (astronomy's) sanctuary and to the privileges and feelings of a votary is only to be gained by one means—sound and sufficient knowledge of mathematics, the great instrument of all exact inquiry, without which no man can ever make such advances in this or any other of the higher departments of science as can entitle him to form an independent opinion on any subject of discussion within their range.

Professor and Mrs. Mittag-Leffler have given their fortune to the founding of an institute for the promotion of research in pure mathematics in Sweden and the other Scandinavian countries. They say:[4]

> Our testament owes its origin to the lively conviction that a people that does not accord to mathematics a high place in its estimation, will never be in a position to fulfil the most lofty tasks of civilization, and to enjoy in consequence that international consideration which is itself, in the end, an effective means of preserving our place in the world and of safeguarding our right to live our own life.

I am not claiming any superiority for mathematics over the other sciences. I am trying to emphasize how indispensable mathematics has been in the development of other sciences. Wherein lies its worth?

Mathematics is an exact science, that is, with the conditions—the postulates—definitely given, the conclusion admits of no doubt, of no variation. The worker in the

[3] Science, Vol. 40 (1914), p. 697.

[4] *Bulletin of the American Mathematical Society*, Vol. XXIII., No. 1 (1916), p. 31.

fields of the natural sciences sees the result —the conclusion—before him and tries to work back to underlying causes. Nature has laid a foundation and reared thereon a mighty superstructure, through which the natural scientist wanders amid a maze of halls and chambers, scratching the surface a little here and a little there trying to find what sort of a foundation can support all this that he sees. The natural scientist accepts as his foundation that theory which best explains the results. The theory may be wrong, but it serves all the purposes of a scientific theory if it explains to a fair degree of satisfaction observed phenomena. I seem to remember to have read the statement of a physicist that we should probably explain some phenomena of light on the wave theory and other phenomena on the atomic theory. Whenever a theory is contradicted by experiments, the natural scientist seeks another. This may seem a rather "hit or miss" way of scientific research, but it is the best that man can hope for with his human intellect trying to find first causes underlying the workings of a universe.

The mathematician is not thus restricted. He lays his own foundation. Some natural science may furnish the material for this foundation, but the mathematical mason handles each stone and sets it in proper relationship in the mortar of consistency.

By being an exact science, mathematics serves the natural sciences in two ways. In the first place, the methods of mathematical deduction offer a convenient means of testing the consistency of a theory. Mathematics will take the essential elements of a theory as postulates and deduce the necessary conclusions. If this leads to a contradiction of experiment, the incorrectness of the theory is shown. It might even be possible in certain cases to locate exactly what part of the theory is at fault. If the deduced results agree with experiment our faith in our theory is strengthened. An example of this sort of thing is to be found in Carmichael's "Theory of Relativity." The author, a mathematician, has taken as his postulates statements whose truth is accepted by a number of physicists. He has arrived, by purely mathematical means, at results whose truth or falsity are susceptible of experimental proof. The results of such an experiment as he suggests would disprove or increase our faith in the truth of his postulates.

A second way in which this exact science can serve the natural sciences, and which does not differ much from the way already mentioned, is in the matter of discovery. If the postulates of a natural theory are true, then all its consequences are true. Mathematics offers a tool for finding out these consequences. A classic example of discovery in this manner is Maxwell's prediction of the pressure due to heat or light radiation, which was not experimentally demonstrated for several years after Maxwell's death. Sir W. R. Hamilton's prediction of conical refraction is another such example. This prediction was experimentally verified by his colleague Lloyd within a short time after it was announced. This mathematical working out of the consequences of a theory has, in my judgment, not received its due at the hands of the natural scientist.

A more universal service rendered by mathematics has been the furnishing of a system of shorthand that is as exact and much more workable than the completely written out statement. If you do not believe in the value of a well-chosen symbolism, try to calculate the value of $22\frac{1}{3}$ dozen eggs at $39\frac{1}{2}$ cents per dozen by using Roman notation. A well-known example of the value of symbolism is furnished by mathematics itself in the development of the

calculus. Newton and Leibnitz made independent discoveries in this field. Newton chose a rather clumsy notation, Leibnitz our present notation. The English mathematicians used the Newtonian notation and were hampered to such an extent that they fell far behind the continental mathematicians in the development of the calculus. The graph is an example of an almost universal scientific symbol for representing tabulated data. Some one has said that we capitalize our knowledge in an equation. The natural scientist finds a well-developed symbolism in mathematics and proceeds to make use of it without taking the trouble of creating one of his own.

I have spoken of the service of mathematics to the natural sciences. There is a return service. The natural sciences furnish a rich field for mathematical research. One of the problems that has called forth the efforts of many mathematicians in the recent past has been the three body problem. There are many others of lesser note and many more still untouched. In a number of the *Bulletin of the American Mathematical Society* for 1914, there appeared a letter from a Mr. Paaswell, an engineer, enumerating a number of engineering problems which he thinks the mathematician should attack. Physics and mathematics have acted and reacted upon each other to the enrichment of both. Witness the work of J. C. Maxwell.

The natural sciences and developments based upon them not only furnish a rich field for mathematical research, but a field which promises to quickly make mathematics of service to the world. The scientist in any field feels justified in his labors if he discovers new facts, whether or not they are immediately applicable to the problems of daily life. He hopes they will be serviceable some day. The investigator in pure mathematics may work for the pleasure he gets from his mental creations, but in most men there is the deeper purpose of serving the world. The natural sciences furnish a field for the choice of postulates, the development of the consequences of which gives prospect of practical worth in the immediate future.

The mathematician is always confronted by the question of the consistency of his postulates. If these are chosen from some natural science, he can often find some physical system in which his postulates are verified. This exhibition of an example in which the postulates are verified and which from the fact of its physical existence offers no contradictory conclusions, is the best proof of consistency.

In our colleges and technical schools the time the engineering student or student of pure science gives to mathematics is reduced to a minimum in order to make room for more technical subjects, and in our graduate schools the mathematical student is given little opportunity to study anything but pure mathematics. The result is that one group of students knows too little mathematics to develop properly their field of study and the other group knows too little of the natural sciences and their application to apply to them their knowledge of mathematics.

How can we remedy this? I do not know. Not every engineering student or student of pure science should be required to become proficient in mathematics, nor every mathematician be required to become an engineer. This would be a great waste of time and effort without commensurate returns. The sooner, however, some plan is worked out whereby the pure science or engineering student of marked mathematical ability is given a chance to develop that ability, or the mathematical student with a tendency to applied mathematics is given opportunity in that direction, the sooner

will come the time of fullness of the development of applied science.

Mathematics has been a well-nigh indispensable tool in the development of the natural sciences and their applications. On the other hand the natural sciences and particular problems set by science have challenged the ability of mathematicians and spurred them on to the achievement of larger results in pure mathematics. Whoever can strike this flint of mathematics upon the steel of natural science and produce fire is doing the world service. The oftener fire is produced the greater will be the development of both mathematics and natural science.

THOS. E. MASON

PURDUE UNIVERSITY

EDUCATION AFTER THE WAR

THE sharp debate on the place of science in education which took place recently in the House of Lords between Lord Haldane on the one side and Lord Cromer and Viscount Bryce on the other side is an example of the kind of misunderstanding which it is necessary to eliminate if we here in the United States and you in England are to act wisely in the matter of education after the war.

In his sesquicentennial address at Princeton University nineteen years ago Woodrow Wilson said that if he was not mistaken the "scientific spirit" of the age is doing us a great disservice, working in us a certain great degeneracy; and yet he said that he had no indictment against science itself, but only a warning to utter against the atmosphere which has stolen from our laboratories and lecture rooms and into the general air of the world at large. It is a noxious intoxicating gas which has somehow got into the lungs of the rest of us, a gas which it would seem forms only in the outer air.

Now it is not easy even for one of Dr. Wilson's training to express himself with perfect clearness in a matter of this kind; and although we are in full sympathy with what we understand Dr. Wilson's point of view to be, we do not like his use of the term "scientific spirit." The true scientific spirit, the spirit of such men as Kelvin and Helmholtz, is beyond criticism; but the great things such men have done have brought upon us the most distressing and stupid form of idolatry the world has ever seen, and the men who have the true scientific spirit are the only men, as a rule, who are free from it.

Science is *finding out* and *learning how*, whereas most people think of science only in terms of its material results. These results have indeed fascinated the crowd, and the great majority of men have adopted a scale of physical values for everything in life "with a consequent neglect of quality and a denial of human value in everything. We have a philosophy of rectangular beatitudes and spherical benevolences, a theology of universal indulgence, a jurisprudence which will hang no rogues; all of which means, in the root, incapacity of discerning worth and unworth in anything and least of all in man. Whereas, nature and heaven command us, at our peril, to discern worth from unworth in everything and most of all in man."

"Our real problem now, as always, is 'Who is best man?' and the fates forgive much—forgive the wildest, fiercest and crudest experiments—if fairly made in the settling of that question. Theft and blood-guiltiness are not pleasing in their sight, and yet the favoring powers of the spiritual and material worlds will confirm to you your stolen goods, and their noblest voices applaud the lifting of your spear and rehearse the sculpture of your shield, if only your robbing and slaying have been done in fair arbitrament of that question 'Who is best man?' But if you refuse such inquiry you will come at last to face the same question wrong side upwards, and your robbing and slaying must then be done to find out 'Who is *worst* man ?' which in so wide an order of inverted merit is indeed not easy."

This impassioned statement of a great English writer and moralist seems to us to touch the essence of all unfriendliness towards the sciences among seriously thoughtful men, and although this unfriendliness is largely mis-

directed it must be admitted that "side by side with great advances in material prosperity due largely to the applications of science there has been a vast deterioration of character," as Lord Cromer expressed it.

Indeed Lord Cromer applied his statement particularly to the Germans, but the deterioration of character, which has shown itself chiefly in the misuse of wealth and opportunity, is by no means confined to the Germans. In some respects, indeed, it would seem that the English and our own Americans have sinned more than the Germans.

Lord Haldane and all champions of science teaching should understand that most of the unfriendliness towards science is a hatred of material worship; and Lord Cromer and Viscount Bryce should understand that in their opposition to the extension of science teaching they are misdirecting their hatred of idolatry, and placing themselves in exactly the position of the hand spinners when they opposed the introduction of improved machinery years ago. It is now as much of a mistake to oppose the fullest and widest possible development of finding out and learning how as it was years ago to oppose labor-saving machinery; only it is quite necessary to make readjustments for the conservation of character and morals. Indeed this necessity has shown itself most distinctly in our reluctance to make just such readjustments among those whose labor has been so wonderfully "saved" by machinery!

In the early days at the University of Kansas (where one of us graduated thirty years ago) when the crudities of pioneer living were still very much in evidence the question was frequently raised among the young men of the faculty who had come from older communities in the east "Can the finer aspects of civilization, literature and the fine arts, ever flourish in this prairie country?" And a smaller faculty group, sensitized by the raw conditions, were very much alive to the question which has been fought over in every college "This new thing, science, what menace does it hold for literature and the fine arts?" Let one consider what must have been the state of mind of an immigrant group of intellectuals in grasshopper times in Kansas!

Nothing, perhaps, is farther from the ideals and methods of the mathematical sciences than literature and music and painting and sculpture, and yet many of our greatest scientists and engineers have held the artistic temperament to be the most important qualification for the investigator or builder. It certainly is not foolish, at any rate, to consider seriously the unfriendliness towards science teaching among those whose work is more closely connected with human things. Lord Cromer and Viscount Bryce no doubt agree with Woodrow Wilson in having no indictment against science itself, but they seem somehow to be unfriendly towards science teaching.

> Da wird der Geist Euch wohl dressirt
> In spanische Stiefeln eingeschnuert.

Indeed there is a phase of science teaching for which there is an unfriendly feeling among those whose work is closely connected with experimental science and engineering, namely, formal mathematics teaching, and nothing has ever been said which can be more justly applied in criticism of our conventional courses in mathematics than the following criticism of conventionalized art. The criticism is expressed in terms of the contrast between the two paths of art and it is illustrated by examples chosen from early barbarisms.

The substitution of conventionalism for sympathy with observed life is the first characteristic of the hopeless work of all ages, and it is eminently manifested in the accompanying picture of an angel from a psalter of the eighth century which is to be found in the library of St. John's College, Cambridge. This angel is a barbarism

Fig. 1. An angel of the eighth century. The beginnings of art in England.

from which nothing could emerge, for which no future was possible but extinction. It represents an utterly dead school of art which closed its eyes to natural facts (for however ignorant a person may be he need only look at a human being to see that it has a mouth as well as eyes) and made the attempt to adorn or idealize natural facts according to its own notions (for it put red spots in the middle of the hands and sharpened the thumbs, thinking to improve them). Here you have an example of the worst that is possible in idealism. Whenever people don't look at nature they always think they can improve her.

From this dead barbarism let us turn to a living barbarism, to work done by hands as rude and by minds as uninformed, let us turn to a picture of the Serpent Beguiling Eve, from the Church of St. Ambrogio of Milan. Its date is not known, but it is barbarous enough for any date: but rude and ludicrous as the sketch is, it does certainly have the elements of life in it. The workman's whole aim was straight at the facts, and not merely at the facts but at the very heart of the facts, for he did indeed show Eve's state of mind, that she is pleased at being flattered and yet in an uncomfortable mood of hesitation; some look of listening, of complacency and embarrassment he did verily get into the picture; note the eyes slightly

FIG. 2. The Serpent Beguiling Eve. The beginnings of art in Italy.

askance, the lips compressed and the right hand nervously grasping the left arm. Nothing was impossible to the people who began their art thus. The world was open to them and all that is in it; whereas nothing was possible to the man who did the symmetrical angel, the world was keyless to him. He built a cell for himself in which he was barred up forever.

Our conventionalized courses in mathematics do not, however, take strong enough hold on young men to shut them up, as in a cell, forever! No, they certainly do not! But these courses do tend to separate ordinary mathematical ideas from sense material: whereas the very essence of physics and chemistry is to develop mathematical ideas in connection with sense material.

Let no one imagine that we, in our unfriendliness towards conventional mathematics teaching fail to appreciate the necessity of the kind of precise thinking which is peculiar to the mathematical sciences, although much that has been said on this subject by mathematicians seems to us to be only a near-vision of that abstract heaven which, according to William James, is the one refuge of tender-minded philosophers, but which to the tough-minded is merely an empty dream.

Nothing in this world is necessary which can be avoided, and it is much better to attempt to show that we can not get along without precise thinking than it is to pronounce eulogy thereon; and if one speaks of the necessity of precise ideas as a distressing thing, which it certainly is to many young men who aspire to be engineers and scientists, one may as it were by stealth gain entrance to their primitive minds and convince them that men do not now live by hunting and fishing. This is what we have tried to do in our "Introduction to Mechanics."[1]

Imagine a never-to-be-escaped human need of a twenty-foot arm. What age-long development, and what unthinkable pains! It is easier to build a steam shovel! All of which means that *homo sapiens* is now bent towards social inheritance; but social inheritance has its own pains, as many know who burn the midnight oil.

Weh dem die Enkeln sind.[2]

How shocking to reduce the tender-minded philosopher's love for perfect precision to a materialistic preference for steam shovels as

[1] See our "Mechanics and Heat," The Macmillan Co., 1910. This essay is reprinted under the title The Study of Science in "Bill's School and Mine," published by Franklin, MacNutt and Charles, South Bethlehem, Pennsylvania, 1913.

[2] This was addressed by Goethe directly to a young student "Weh dir das du ein Enkel bist."

opposed to immeasurable pains of birth! And to make mathematical philosophy appear as a dire necessity rather than a thing to be chosen for its own sake.[3] And then to urge[4] with that lover of paradox, Gilbert Chesterton, that the serious spiritual and philosophic objection to steam shovels is not that men work at them and pay for them and make them very ugly, nor even that men are killed by them, but merely that men do not play at them! Imagine a group of sportsmen cavorting over a ten-thousand acre field tossing and catching a Brobdignagian ball in steam shovels! Is it conceivable that the one objection to the steam shovel might have been eventually overcome if the Great War had not come upon us?

The greatest danger of our time is the confusion of boundaries between thing-philosophy and human-philosophy, between the philosophy of material conquest and power and that intimate philosophy of comfort which makes life not easy but worth while. When these boundaries are rectified there will be a philosophy of steam shovels recognized and used as such, and another philosophy of living; and the most laughable spectacle in the world will have passed by forever, namely, the Bergson type of philosopher with his following flock of men and women captivated by humbug in the name of an easy, capital-letter science raised heaven-high above all dirt and slime!

W. S. Franklin,
Barry MacNutt

[3] This we have tried to do in our "Introduction to Mechanics."

[4] See preface to Franklin and MacNutt's "Elements of Electricity and Magnetism," The Macmillan Co., 1908.

THE VALUE OF THE SANITARY SURVEY

It would seem unnecessary to again dwell upon the old topic that analytical examinations, whether chemical or bacteriological or both, utterly fail in a large number of cases to supply sufficient data whereon to build an opinion as to the sanitary value of a water; but the old belief is deep-seated and dies hard. From time to time therefore it appears necessary to call attention to the fact that, however valuable the information gained in the laboratory may be, a thorough personal knowledge of the conditions surrounding the source whence the water comes and the method used for taking the sample entirely outweigh the analytical data.

Take an instance: Mr. N. S. Hill had reported to him the presence of *B. Coli* in water from flowing artesian wells, over which wells he had jurisdiction; and he was naturally not a little pained and mystified because of the character of such report, the accuracy of which was beyond dispute. The water rose under pressure sufficient to carry it fifteen or twenty feet above the ground surface and it thence fell in open streams into the funnel-shaped ends of vertical pipes connected directly with the supply main. Deep waters may contain bacteria, especially chromogenic varieties, and even pathogenic forms may occur therein because of unsuspected channel ways in the rock; but under the conditions obtaining in this instance the adverse report of the examiner was unlooked for and Mr. Hill's surprise was fully warranted.

Upon carefully conducted inspection it was observed that at certain times of the day the rims of the above-mentioned funnel-shaped pipe terminals were lined with sparrows that roosted, as often as not, with heads pointed outward.

Another case of pollution due to birds had a more serious ending. The contractor was confident of the purity of the water he had engaged to supply and rested his case upon the report of a bacteriologist selected by both parties. The report was adverse to the fitness of the water and caused financial failure of the contractor. When it was too late to rectify the error it was discovered that the small basin which caught the water as delivered from the ground had served as a roosting place for birds and from that basin, rather than from the falling stream, the sample had been taken.

During a legal inquiry concerning what could or could not be done by the addition of alum to a city water-supply, much discussion

was had over the disadvantage or otherwise of using the chemical and considerable excitement followed its detection at the city faucets. Material doubt was afterwards thrown upon the accuracy of the determination and upon what may be termed "prophetic taste" when it was noted that the presence of alum had been detected some four days before it was added to the raw water.

A large town was desperately in need of water and an excellent ground supply was located. The health officer, a physician who was not in favor of the proposed plan, sampled the water, carried the sample under his buggy seat during his professional visits in the country and in the course of a day or two forwarded it, by express, without ice packing, to the central authorities who condemned it upon the strength of the high count of bacteria without having ever visited the well.

An outbreak of typhoid fever manifestly due to transmission by flies occurred in a city during a period when certain repairs were being made to the conduit leading from the source of the public water. Outside authorities to whom the situation was referred reported the outbreak of disease as probably caused by the entrance of the repair gang into the tunnel carrying the municipal supply. A visit to the spot would have convinced the writers of the report of the impossibility of getting the said gang into the twenty-inch cast-iron pipe.

The duties of the water examiner, however, do not always limit him to use the sanitary survey to save a good water from unfair condemnation. Quite otherwise. A water of entirely satisfactory character judged from the laboratory standpoint may be rated as undesirable upon inspection of local conditions because of proposed changes in the immediate vicinity of the source.

A spring water of high quality was condemned because arrangements had been made to construct a sewer above the spring and near it. The engineer in charge was to construct a "tight sewer," but who could guarantee that it would stay tight? A glance at the tables showing the leakage of ground water into sewers should shake one's faith in the permanence of such "tightness," and sewers not tight can allow of leakage out as well as in.

Damage to water through "new construction" is very fruitful of adverse and unfair reports. Springs of unassailable purity become temporarily injured (solely from the laboratory standpoint) because of "developments" made with a view to improve the surroundings. New wells and recently "improved" springs will furnish waters likely to be condemned by laboratory standards and samples of their waters should therefore not be submitted for examination.

Finally, while it is admitted that laboratory methods of water analysis have made great strides towards perfection during recent years, they can never hope to reach such perfection as to enable the analyst to uniformly rest upon chemistry and bacteriology alone, without aid from the actual sanitary survey, and they can still less be depended upon to furnish information not on what a water is, but on what it is likely to become.

W. P. MASON

TROY, N. Y.,
September 25, 1916

THE CONVOCATION-WEEK MEETINGS OF SCIENTIFIC SOCIETIES

THE American Association for the Advancement of Science and the national scientific societies named below will meet at New York City, during convocation week, beginning on Tuesday, December 26, 1916:

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—President, Charles R. Van Hise, president of the University of Wisconsin; retiring president, Dr. W. W. Campbell, director of the Lick Observatory; permanent secretary, Dr. L. O. Howard, Smithsonian Institution, Washington, D. C.; general secretary, Professor W. E. Henderson, Ohio State University; secretary of the council, Dr. C. Stuart Gager, Brooklyn Botanical Garden.

Section A—Mathematics and Astronomy.—Vice-president, Professor L. P. Eisenhart, Princeton University; secretary, F. R. Moulton, University of Chicago, Chicago, Ill.

Section B—Physics.—Vice-president, Professor H. A. Bumstead, Yale University; secretary, Dr.

W. J. Humphreys, U. S. Weather Bureau, Washington, D. C.

Section C—Chemistry.—Vice-president, Professor Julius Stieglitz, University of Chicago; secretary, Dr. John Johnston, Geophysical Laboratory, Washington, D. C.

Section D—Mechanical Science and Engineering.—Vice-president, Dr. H. M. Howe, Columbia University; secretary, Professor Arthur H. Blanchard, Columbia University, New York City.

Section E—Geology and Geography.—Vice-president, Professor R. D. Salisbury, University of Chicago; secretary, Professor George F. Kay, University of Iowa.

Section F—Zoology.—Vice-president, Professor G. F. Parker, Harvard University; secretary, Professor Herbert V. Neal, Tufts College, Mass.

Section G—Botany.—Vice-president, Dr. C. Stuart Gager, Brooklyn Botanical Garden; secretary, Dr. A. F. Blakeslee, Cold Spring Harbor, N. Y.

Section H—Anthropology and Psychology.—Vice-president, Dr. F. W. Hodge, Bureau of American Ethnology; secretary, Professor George Grant MacCurdy, Yale University, New Haven, Conn.

Section I—Social and Economic Science.—Vice-president, Louis F. Dublin, Metropolitan Life Insurance Company; secretary, Seymour C. Loomis, 69 Church Street, New Haven, Conn.

Section K—Physiology and Experimental Medicine.—Vice-president, Professor Edwin O. Jordan, University of Chicago; secretary, Professor C.-E. A. Winslow, Yale University.

Section L—Education.—Vice-president, Dr. L. P. Ayres, The Russell Sage Foundation; secretary, Dr. Stuart A. Courtis, Detroit, Mich.

Section M—Agriculture.—Vice-president, Dr. W. H. Jordan, director of the New York Agricultural Experiment Station; secretary, Dr. E. W. Allen, U. S. Department of Agriculture, Washington, D. C.

American Mathematical Society.—December 27 and 28. President, Professor Ernest W. Brown, Yale University; secretary, Professor F. N. Cole, 501 West 116th St., New York, N. Y.

Mathematical Association of America.—December 28, 29 and 30. President, Professor E. R. Hedrick, University of Missouri; secretary, W. D. Cairns, 5465 Greenwood Ave., Chicago, Ill.

American Astronomical Society.—December 26 to 30. President, Dr. E. C. Pickering, Harvard College Observatory; secretary, Dr. Philip Fox, Dearborn Observatory, Evanston, Ill.

American Federation of Teachers of the Mathematical and the Natural Sciences.—Council meeting. Secretary, W. A. Hedrick, Central High School, Washington, D. C.

American Physical Society.—December 26 to 30. President, Professor R. A. Millikan, University of Chicago; secretary, Professor Alfred D. Cole, Ohio State University, Columbus, Ohio.

Optical Society of America.—December 28. President, Dr. Perley G. Nutting, 3 Kodak Park, Rochester, N. Y.

American Chemical Society.—President, Dr. Charles H. Herty, New York City; secretary, Dr. C. L. Parsons, U. S. Bureau of Mines, Washington, D. C.

American Electrochemical Society.—Chairman, New York Section, Dr. Colin G. Fink, Edison Lamp Works, Harrison, N. J.

Society for the Promotion of Engineering Education.—President, Professor H. S. Jacoby, Columbia University; secretary, Professor F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Illuminating Engineering Society.—President, W. J. Serrill; chairman, Committee on Reciprocal Relations, Clarence L. Law, Irving Place and 15th St., New York, N. Y.

Association of American Geographers.—December 28 to 30. President, Dr. Mark Jefferson, Michigan State Normal College, Ypsilanti, Mich.; secretary, Professor Isaiah Bowman, Yale University, New Haven, Conn.

American Alpine Club.—December 30. President, H. G. Bryant; secretary, Howard Palmer, New London, Conn.

American Society of Naturalists.—December 29. President, Dr. Raymond Pearl, Maine Agricultural Experiment Station; secretary, Professor Bradley M. Davis, University of Pennsylvania, Philadelphia, Pa.

American Society of Zoologists.—December 27, 28 and 29. President, Professor D. H. Tennent, Bryn Mawr College; secretary, Professor Caswell Grave, Johns Hopkins University, Baltimore, Md.

Entomological Society of America.—December 26 and 27. President, Dr. E. P. Felt; secretary, J. M. Aldrich, West Lafayette, Ind.

American Association of Economic Entomologists.—December 28, 29 and 30. President, Dr. C. Gordon Hewitt, Department of Agriculture, Ottawa, Canada; secretary, Albert F. Burgess, Melrose Highlands, Mass.

AMERICAN GENETIC ASSOCIATION.—December 26, 27 and 28. President, David Fairchild, U. S. Department of Agriculture; secretary, George M. Rommel, 511 11th St., Washington, D. C.

EUGENICS RESEARCH ASSOCIATION.—President, Professor Adolf Meyer, The Johns Hopkins University; secretary, William F. Blades, 191 Haven Ave., New York, N. Y.

ECOLOGICAL SOCIETY OF AMERICA.—December 27, 28 and 29. President, Professor V. E. Shelford, University of Illinois; secretary, Forrest Shreve, Desert Botanical Laboratory, Tucson, Ariz.

BOTANICAL SOCIETY OF AMERICA.—December 27 to 30. President, Professor R. A. Harper, Columbia University; secretary, Dr. H. H. Bartlett, University of Michigan, Ann Arbor, Mich.

AMERICAN PHYTOPATHOLOGICAL SOCIETY.—December 27 to 30. President, Dr. Erwin F. Smith, U. S. Department of Agriculture; secretary, Dr. C. L. Shear, U. S. Department of Agriculture, Washington, D. C.

AMERICAN FERN SOCIETY.—December 29. President, Dr. C. H. Bissell, Michigan Agricultural College; secretary, C. A. Weatherby, 920 Main St., East Hartford, Conn.

SULLIVANT MOSS SOCIETY.—December 29. President, Mrs. Elizabeth G. Britton, N. Y. Botanical Garden; secretary, Edward B. Chamberlain, 18 West 89th St., New York, N. Y.

SOCIETY OF HORTICULTURAL SCIENCE.—December 28, 29. Secretary, C. P. Close, U. S. Department of Agriculture, Washington, D. C.

ASSOCIATION OF OFFICIAL SEED ANALYSTS.—Will meet on dates to be announced. Secretary, John P. Helyar, New Brunswick, N. J.

SOCIETY OF AMERICAN FORESTERS.—Meets on Friday, December 29. President, Dr. B. E. Fernow, University of Toronto; secretary, C. R. Tillotson, U. S. Forest Service, Washington, D. C.

MID-WEST FORESTRY ASSOCIATION.—President, Fred W. Smith, State School of Forestry, Bottineau, N. Dak.

AMERICAN MICROSCOPICAL SOCIETY.—Business sessions. President, Professor M. F. Guyer, University of Wisconsin; secretary, Professor T. W. Galloway, Beloit College, Beloit, Wis.

AMERICAN ANTHROPOLOGICAL ASSOCIATION.—December 26 to 29. President, Dr. F. W. Hodge, Bureau of American Ethnology; secretary, Professor George G. MacCurdy, Yale University Museum, New Haven, Conn.

AMERICAN FOLK-LORE SOCIETY.—December 27. President, Dr. R. H. Lowie, American Museum of Natural History; secretary, Charles Peabody, Harvard University, Cambridge, Mass.

AMERICAN PSYCHOLOGICAL ASSOCIATION.—December 27 to 30. President, Professor Raymond Dodge, Wesleyan University; secretary, Professor R. M. Ogden, Cornell University, Ithaca, N. Y.

AMERICAN PHILOSOPHICAL ASSOCIATION.—December 27, 28 and 29. President, Professor A. O. Lovejoy, The Johns Hopkins University; secretary, Professor E. G. Spaulding, Princeton University, Princeton, N. J.

AMERICAN SOCIETY OF BACTERIOLOGISTS.—December 29. Secretary, A. P. Hitchens, Glen Olden, Pa.

AMERICAN ASSOCIATION OF ANATOMISTS.—December 27, 28 and 29. President, Dr. H. H. Donaldson, Wistar Institute of Anatomy; secretary, Professor C. R. Stockard, Cornell Medical School, New York, N. Y.

AMERICAN PHYSIOLOGICAL SOCIETY.—December 27, 28, 29 and 30. President, Professor W. B. Cannon, Harvard Medical School; secretary, Professor Charles W. Greene, University of Missouri, Columbia, Mo.

AMERICAN SOCIETY OF BIOLOGICAL CHEMISTS.—December 27, 28 and 29. President, Professor Walter Jones, The Johns Hopkins University; secretary, Dr. Stanley R. Benedict, Cornell Medical College, New York, N. Y.

AMERICAN SOCIETY FOR PHARMACOLOGY AND EXPERIMENTAL THERAPEUTICS.—December 28, 29 and 30. President, Professor Reid Hunt, Harvard Medical School; secretary, Dr. John Auer, Rockefeller Institute, New York, N. Y.

AMERICAN SOCIETY FOR EXPERIMENTAL PATHOLOGY.—December 28, 29 and 30. President, Simon Flexner, The Rockefeller Institute; secretary, Dr. Peyton Rous, Rockefeller Institute, New York, N. Y.

(*The above four societies compose the Federation of American Societies for Experimental Biology. Executive Secretary, Dr. Peyton Rous.*)

AMERICAN NATURE-STUDY SOCIETY.—December 27. President, Professor L. H. Bailey, Ithaca, N. Y.; secretary, E. R. Downing, University of Chicago, Chicago, Ill.

SCHOOL GARDEN ASSOCIATION OF AMERICA.—December 29 and 30. President, Van Evrie Kilpatrick, 124 West 30th St., New York, N. Y.

Gamma Alpha Graduates Scientific Fraternity.—Will meet on dates to be announced. President, Professor W. J. Meek, University of Wisconsin; recorder, L. C. Johnson, 2018 Madison St., Madison, Wis.

Society of the Sigma Xi.—December 27. President, Dr. Charles S. Howe, Case School of Applied Science; secretary, Professor Henry B. Ward, University of Illinois, Urbana, Ill.

American Association of University Professors.—December 29 and 30. President, Dr. John H. Wigmore, Northwestern University; secretary, Dr. H. W. Tyler, Massachusetts Institute of Technology.

SCIENTIFIC NOTES AND NEWS

The following is a list of those recommended by the president and council of the Royal Society for election at the anniversary meeting on November 30: *President,* Sir J. J. Thomson, O.M., M.A., D.Sc., LL.D.; *Treasurer,* Sir A. B. Kempe, M.A., D.C.L.; *Secretaries,* Professor A. Schuster, Sc.D., Ph.D., and W. B. Hardy, M.A.; *Foreign Secretary,* Professor W. A. Herdman, D.Sc.; *Other Members of the Council,* Professor J. G. Adami, M.D., H. T. Brown, LL.D., Dugald Clerk, D.Sc., Professor A. R. Cushny, M.D., Professor A. Dendy, D.Sc., Professor P. F. Frankland, LL.D., Professor J. W. Gregory, D.Sc., H. Head, M.D., J. H. Jeans, Major H. G. Lyons, Major P. A. McMahon, D.Sc., Professor F. W. Oliver, D.Sc., Professor C. S. Sherrington, M.D., Professor A. Smithells, B.Sc., Hon. R. J. Strutt, M.A., and R. Threlfall, M.A.

As has been noted in Science Dr. Wilhelm Waldeyer, professor of anatomy at the University of Berlin since 1883, was raised to the hereditary peerage on the occasion of his eightieth birthday on October 6. The *Journal* of the American Medical Association states that a bronze portrait plaque was presented to him by his present and former pupils, and a duplicate was hung in the headquarters of the Postgraduate Instruction System. He has been chairman of the central committee of this work for many years. The Leopold-Karolinische Akademie of Halle presented him with the gold Cothenius medal, and honorary memberships in various scientific and other societies poured in on him. He announced that although he was thinking of retiring from his teaching chair at the university at the close of this semester, yet he intended to keep up his other work.

Sir Frank Dyson, astronomer royal, Professor R. A. Sampson, astronomer royal for Scotland and professor of astronomy in the University of Edinburgh, and Professor H. C. Plummer, astronomer royal of Ireland and Andrews professor in the University of Dublin have been elected honorary members of the British Optical Society.

Dr. Henry Head, F.R.S., physician to the London Hospital and editor of *Brain,* has been added to the government committee which, under the chairmanship of Sir J. J. Thomson, president of the Royal Society, is inquiring into the position occupied by natural science in the educational system of Great Britain, especially in secondary schools and universities.

At a recent meeting of the Royal Astronomical Society, Mrs. R. A. Proctor, widow of the astronomer Richard A. Proctor, was formally admitted as fellow of the society. Exactly 50 years ago, in November, 1866, the late Richard A. Proctor was elected to fellowship.

The University of London has awarded the Rogers prize of £100 for 1916, for an essay on "The Nature of Pyrexia and Its Relation to Microorganisms" to Dr. J. L. Jona.

The trustees of the Massachusetts Horticultural Society have awarded the George Robert White Medal of Honor for the year 1916 to William Robinson, of Gravetye Manor, Sussex, England. The medal, by John Flanagan, is of coin gold, weighs 8½ ounces and was struck at the mint of the United States, Philadelphia. This is the eighth award of this medal made by the society in recognition of eminent service in the advancement of horticulture. Previous awards have been made to Professor C. S. Sargent, of the Arnold Arboretum; Jackson T. Dawson, Victor Lemoine, of Nancy, France; Michael H. Walsh, the rose specialist of Woods Hole; Sir Harry J. Veitch, of London, and Ernest H. Wilson. William Robinson, to whom the medal is now

awarded, has done much, especially through his writings in horticultural literature, as an exponent of the natural style of flower gardening as opposed to the formal bedding and ribbon borders of former years.

THE *Frankfurter Zeitung*, as quoted by the *Journal* of the American Medical Association, has published a statement to the effect that Professor W. Kolle, chief of the Institute for Bacteriology and Hygiene of the University of Bern, has been called to Frankfurt as successor to Ehrlich in the Institute for Experimental Therapy and also in the G. Speyer-Haus. Professor Wassermann, of Berlin, was called first, but he yielded to pressure from the local scientific authorities and finally declined. Professor Hans Sachs, Ehrlich's coworker, has been appointed director of the Institute for Experimental Therapy, and Professor Morgenroth of the Charité, Berlin, is being considered for director of the Speyer Institute.

PROFESSOR A. S. HITCHCOCK, systematic agrostologist, U. S. Department of Agriculture, has returned from a five months' tour of the Hawaiian Islands. He explored in considerable detail the islands of Hawaii, Maui, Molokai, Lanai, Oahu and Kauai, and brought back important collections of plants. He was accompanied by his son, Albert E. Hitchcock, as assistant.

DR. WAICHIRO OCADO, professor of medicine at the University of Tokyo, is making a tour of inspection of the hospitals of the United States.

AT the meeting of the Royal Statistical Society held on November 21, the president, Sir Bernard Mallet, delivered his presidential address on "The Organization of Registration in its Bearing on Vital Statistics."

THE Mineralogical Society, London, has elected the following officers: *President*, Mr. W. Barlow; *Vice-presidents*, Professor H. L. Bowman and Mr. A. Hutchinson; *Treasurer*, Sir William P. Beale, Bart.; *General Secretary*, Dr. G. T. Prior; *Foreign Secretary*, Professor W. W. Watts; *Editor of the Journal*, Mr. L. J. Spencer.

THE Geographical Society of Philadephia celebrated the twenty-fifth anniversary of its founding at the Academy of Natural Sciences on Wednesday evening, December 6. The address of welcome was given by Dr. Samuel G. Dixon, president of the Academy of Natural Sciences, and addresses were made on "Men and Memories of the Early Days of the Society" by Mr. Henry G. Bryant, president of the Geographical Society, and on "Past and Future of the Society," by Dr. Talcott Williams, director of the school of journalism, Columbia University. A reception was held afterwards in the Library Hall of the academy.

DR. W. F. HILLEBRAND, chief chemist of the Bureau of Standards, Washington, D. C., lectured at Columbia University, on November 27, on "Analytical Chemistry and Its Possible Future." This was the second lecture on the Chandler Lecture Fund which was established by former students of the university in honor of Dr. C. F. Chandler, Mitchell professor emeritus of chemistry.

DR. HENRY H. DONALDSON, of the Wistar Institute of Anatomy, will give the fourth Harvey lecture in the New York Academy of Medicine on the evening of December 16. The subject of the lecture is "Growth Changes in the Mammalian Nervous System."

A BUST of John Muir was unveiled at the University of Wisconsin on the evening of December 6. The bust was presented by Mr. T. E. Brittinham to the university where Muir was a student for four years. Dean E. A. Birge presided, and addresses were made by Regent Charles H. Villas and President Charles R. Van Hise.

IN the eighth Kelvin lecture, delivered before the Institution of Electrical Engineers, Dr. Alexander Russell dealt with some aspects of his subject's life and work which are of special interest to engineers.

AN exhibition and sale of water-color sketches by the late Professor Silvanus P. Thompson, the distinguished physicist, was held at the rooms of the Alpine Club, London, from November 27 to December 10.

It is planned to erect at the University of Vermont a memorial to the late Professor N. S. Merrill, of the department of chemistry. A committee for this purpose has been appointed by the Alumni Association with Professor E. C. Jacobs as chairman.

The graduating class of the Long Island College Hospital presented to the college, on December 4, a photographic portrait of the late Dr. Joseph H. Raymond, formerly secretary of the faculty and professor of hygiene. Dr. John D. Rushmore made the address of acceptance.

Dr. Martin I. Wilbert, assistant in the division of pharmacology of the hygienic laboratory, died suddenly in Philadelphia on November 25. By virtue of his work in the preparation of "The Digest of Comments on the U. S. Pharmacopoeia and National Formulary" and his services in the American Medical Association and the American Pharmaceutical Association, Dr. Wilbert was among the most influential men in his profession.

Charles Alfred Pitkin, professor of mathematics and physics at Thayer Academy, South Braintree, since its opening in 1877, died on November 5, aged sixty-three years.

The death is announced, at the age of sixty-eight years, of Dr. C. A. Harrison, for many years engineer in chief of the Northeastern Railway of Great Britain.

C. S. Hägler, a leading surgeon and bacteriologist of Basel, Switzerland, connected with the university but prevented by deafness from a full professorship, has died from cancer, at the age of fifty-four years.

K. B. Pontoppidan, professor of nervous and mental diseases and later of forensic medicine at the University of Copenhagen, has died at the age of sixty-three years. He was one of the pioneers in the modern treatment of the insane, and has been at the head of the Aarhus asylum since 1898.

The trustees of the Elizabeth Thompson Science Fund announce their readiness to consider applications for grants in aid of scientific work. Appropriations are restricted to non-commercial enterprises, and are intended solely for the actual expenses of the investigation, not for the support of the investigator nor for the ordinary costs of publication. Grants are made only for those researches, not otherwise provided for, whose object is broadly the advancement of human knowledge; requests for researches of a narrow or merely local interest will not be considered. Usually grants are not made in excess of three hundred dollars. Applications for grants from this fund should be accompanied by a full statement of the nature of the investigation, of the conditions under which it is to be prosecuted, and of the manner in which the appropriation asked for is to be expended. The application should be sent to the secretary of the board of trustees, Dr. W. B. Cannon, Harvard Medical School, Boston, Mass., who will furnish further details.

The University of Washington campus has been selected as the site of the government mining and metallurgical station for the Pacific Northwest states. Congress has voted an appropriation of $25,000 a year for the maintenance of the station which will serve Washington, Oregon, Idaho, Montana and the coastal regions of Alaska from Ketchikan to Nome. The interior of Alaska will be served by a Fairbanks station. Dorsey A. Lyon, a graduate of Leland Stanford, Jr., University, formerly professor of mining engineering at the University of Washington, a specialist in electro-metallurgy, will be in charge of the station.

We learn from the *Journal of Industrial and Engineering Chemistry* that Director Joseph E. Ralph, of the U. S. Bureau of Engraving and Printing, has made public the plan of the Bureau of Chemistry in its establishment of an experimental dye laboratory, for which Congress appropriated $50,000, the location of which will be on the government's property in Virginia just across the Potomac from Washington. Director Ralph has arranged with Dr. Alsberg to give a practical test to all the colors produced by this experimental laboratory.

Bequests of more than $100,000 each have been left to the Metropolitan Museum of Art

and the American Museum of Natural History by the late James Gaunt, American representative of A. & F. Pears, of London. The bequests are to be paid upon the death of Mr. Gaunt's brother.

UNIVERSITY AND EDUCATIONAL NEWS

THE Carnegie Corporation of New York has appropriated $1,038,500 for the use of the Carnegie Institute, Pittsburgh, according to an announcement made at a meeting of the board of trustees by Mr. Samuel H. Church, the president. The Carnegie Institute of Technology will receive $956,000, while $52,500 will be used for the improvement of the Museum of Fine Arts department and the Carnegie Library School, and $30,000 for contingent expenses. The appropriation makes the total benefaction of Mr. Andrew Carnegie in this connection $28,000,000.

MR. JAMES A. PATTEN, vice-president of the board of trustees of Northwestern University, has made a gift of $134,000 to the university. Of this sum $74,000 will be used as an endowment for the gymnasium, of which Mr. Patten is the donor, and $60,000 as a loan fund for students.

IT is announced from Swansea that Messrs. Baldwins (limited) have given £10,000 to the Technical College there for the endowment of a chair of metallurgy.

THE Chemical Institute of the University of Munster has recently been enlarged and has received an endowment for research. The Prussian parliament voted an appropriation for the purchase of machinery, books and other equipment and a number of metal and dynamic firms have raised additional sums.

THE research departments of Johns Hopkins Medical School are being transferred to the new Hunterian Laboratory Building, located at the corner of Wolfe and Madison Streets. The building is five stories in height, constructed of red brick with sandstone trimmings, and will house the school library and all research laboratories.

THE Case School of Applied Science has arranged an extended course in illuminating engineering with the cooperation of the National Lamp Association, a branch of the General Electric Company, with its headquarters in Cleveland.

THE building of the Indiana University School of Medicine at Indianapolis was damaged by fire on December 7, to the extent of $50,000. A meeting of the trustees has been called to decide whether it is advisable to restore the building or to erect a new building on the grounds of the Robert W. Long Hospital, which is under the control of the university.

ADDITIONS to the instructing staff at the Massachusetts Institute of Technology made by the corporation at its last meeting concerned very largely the new stations for the course in chemical engineering practise. The assistant professors and directors have already been announced; their assistants, who have the grade of instructors are: At Bangor, Wilfred Arthur Wylde; at Everett, William Butler Leach, Jr.; at Niagara Falls, Winthrop Earle Caldwell; at Stamford, Edwin Shellabarger Wallace, and at Allentown, Penna., John Shirley Little. Other appointments are: Frank C. Sheperd, lecturer on valuation of public service and other corporations in the department of civil engineering; Claire W. Ricker and Rudolph F. Zecha, instructors in electrical engineering; Edmond W. Bowler, research assistant in electrical engineering; Azel W. Mack, research assistant in applied chemistry, and Murray P. Horowitz, assistant in biology.

DR. H. H. LLOYD is lecturing on physical chemistry at the Johns Hopkins University, temporarily filling the vacancy caused by the death of Dr. Harry C. Jones.

J. F. WILSON, formerly instructor in electrical engineering at the University of Michigan, has been appointed professor of electrical engineering at Queen's University to take the work of Professor L. W. Gill while the latter is in active military service.

DISCUSSION AND CORRESPONDENCE

OPINIONS ON SOME CILIARY ACTIVITIES

In Science for August 4, 1916, Professor C. Grave has questioned the accuracy of some of my conclusions concerning the ciliary mechanisms of lamellibranchs, dealing with the ingestion of food, that were published in the *Journal of Morphology,* Vol. 26, No. 4.

Those statements of mine which he has difficulty in accepting are:

1. Volume alone determines whether the collected foreign matter that reaches the palps shall proceed to the mouth or shall be sent from the body on outgoing tracts of cilia.

2. A lamellibranch is able to feed only when waters are comparatively clear—when diatoms are brought to the gill surfaces a few at a time. In muddy waters all suspended particles, of whatever nature, are led to outgoing tracts.

3. There is no selection or separation of food organisms from other water-borne particles.

4. The direction of the beat of cilia is never changed.

The only facts bearing on these statements, that are offered from Professor Grave's own experience, are those derived from an oyster-feeding experiment made at Buzzards Bay, and these bear only on the second statement, namely, that lamellibranchs feed only when waters are comparatively free from suspended particles.

Professor Grave has referred fully enough for the purpose, to the litigation that led to his experiment. Planted oysters had died in great numbers at the mouth of the Monument River after dredging operations were begun in the oyster field, and below it in Buzzards Bay. He wished to show that oysters could live in the turbid water. Taking individuals gathered at a distance, he deprived them of food for three days, then at a certain point immersed them "in the turbid water" for periods of one, two and three hours, at the end of which periods their stomachs contained from 2,850 to 18,500 food particles. In some cases, also, there was so much sediment that a diatom count was not possible. Some oysters were allowed to remain on the bottom for two weeks, and "all thrived and made perceptible growth of shell."

My contention, based on thousands of examinations of the operation of the palps in very many species of lamellibranchs, and extending through many years, was that when solid particles in sufficient volume are brought to the apposed palp surfaces, they overflow the narrow tracts leading to the mouth from either side, so as to touch outgoing tracts that border them, and by these are carried away and eventually removed from the body. My assumption was that, in this particular case, waters had, during long intervals, been so laden with fine sand and bast fibers from decaying vegetable matter, liberated by the dredging operations, that oysters over the field in general had been, through the action of the ciliary mechanisms of the palps, so often deprived of nourishment that they were gradually weakened and finally destroyed. They were not killed at once, for during a part of the ebb tide relatively clear water coming down from flats above the bay presented conditions favorable for feeding. Some had remained alive for more than two years under the adverse conditions. Here and there even the young had grown for a time. The condition of the field in 1911 indicated, and the owners of the beds testified, that, in general, there had been a gradual elimination.

The results of Professor Grave's feeding experiment seems to him to "show conclusively that oysters can and did feed actively in waters that were turbid with sediment, a fact that is in direct opposition to Dr. Kellogg's conclusion numbered (2) in this paper [and in the present one], and one that casts doubt upon the correctness of the three other conclusions herein discussed."

During a period of two weeks, Professor Grave's oysters "thrived and made perceptible growth of shell." This is not a very full or definite statement of his net results in the matter of growth, but it is all that he has given. At the same time, it was the testimony of all the oyster planters, as well as my own, after I had examined their beds, that, far from thriving, a large proportion of their planted oysters had died, after several months—so

many that the oystermen had almost entirely abandoned the field, and sought other occupation. This fact was completely established. Professor Grave admits an "unusually large" death rate, adding that the "planters readily imagined that the poor condition and death of their oysters were in some way causally connected with this sediment in the water." Commissioners, then referees, and finally a jury, readily imagined the same thing, and awarded them damages for their losses. Why should Professor Grave's oysters have thrived while those of the oystermen died?

It is not without interest that the death of the planted oysters, and other lamellibranchs on the same ground, could not be accounted for by the presence of starfish, drills or other enemies, or from any disease. On the other hand, Professor Grave's oysters may have survived for two weeks, and added a "perceptible growth" to the shell for several possible reasons.

A few of the bed oysters had lived, not two weeks, but two years or more after dredging had begun. A good many survivors were found behind a bar that deflected one of the two main flood currents away from them. The accident of position may have been favorable to Professor Grave's oysters, but they would have lived much longer than two weeks anywhere on the beds.

During the summer of 1911, when this experiment was made, dredging was intermittent. Frequently so little of it was being done that the flood tides bore comparatively little sediment over the beds.

Again, at the time of this experiment most of the dredging was being done at a much greater distance from the beds than formerly, and the water was proved to bear very much less silt than in 1909 and 1910 when the mortality on the beds had been greatest. This fact alone should be sufficient to explain Professor Grave's result.

That oysters in good condition, "gathered from a bed far removed from the scene of the dredging operations," should fail in two weeks to become emaciated—or should thrive—was to be expected. Nor, considering the possible conditions, was I surprised at Professor Grave's results in his examination of the contents of their stomachs. I was not able to see that the fact that his oysters fed "in waters that were turbid with sediment" was at all in opposition to my conclusion. "Turbid with sediment" is a relative—a very indefinite—term. I believe that any lamellibranch is able to take into its stomach any suspended particles, sand grains as well as diatoms, even in turbid water, until a definite point is reached at which they become too numerous, and that then they are all carried out of the body. It is unfortunate that in my work on the ciliary mechanisms I have not determined precisely how turbid the water must be, that is, how large a proportion of suspended matter must be present, to bring the discharging mechanism into action; but in my experiments there was always such a point. Professor Grave asserts his disbelief even in the existence of a normal mechanism of this kind as I have described it, though I have no reason to think that he ever took the trouble to look for it. I am not particularly anxious over final judgment on that matter, or on the "Kellogg theory" of its operation.

The most interesting of Professor Grave's assumptions, however, concern food selection, and my statement that the beat of cilia is nowhere reversed. He contends that cilia of "certain tracts" of the palps are capable of being reversed, as in the case of the oyster, "resulting perhaps from their stimulation directly or indirectly by food particles," and that this "may be the mechanism by which the selection is effected."

One is a little puzzled to understand, from the statement of it, what is the mechanism and its operation according to the Grave theory. Does the reversal of cilia from stimulation by food particles cause the rejection of food particles? If so, to what purpose? Or does stimulation by *food* cause the rejection of *sand,* and not of food particles? That would be interesting. Professor Grave's theory credits the oyster with the possession of a delicate sense of taste, and he is rather scornful because mine does not. Does the taste of sand,

like the taste of crab juice in the case of *Metridium* mentioned by Professor Grave, cause its acceptance, or perhaps its rejection? He says only that food particles, and not that sand or other matter in suspension, cause the reversal that results somehow in the selection of something, either food or material not useful as food, it is difficult to determine which. I judge that some diatoms are rejected, and that other diatoms, and sand, are selected. *Rhizosolenia,* "abundant in salt water, are seldom found in the digestive tract of the oyster." They are not excluded on account of their spiny structure, we are told, because their size is not sufficiently great to prevent their being carried by cilia currents or entering the mouth. Has Professor Grave made observations to determine whether their spiny structure or size is great enough to cause their rejection by the outgoing tracts that, up to this time, I had supposed I had seen in a very great many instances? I must say that I have not, myself, in the case of this particular diatom; but I have seen certain other diatoms excluded, though not in the oyster.

And according to this view, it seems necessary to assume that sand is selected and sent into the mouth, for Professor Grave tells us that it is a "fact that the stomach contents of oysters always contain a larger volume of sand than of food organisms." I am grateful to him for adding that this is difficult to explain on the Kellogg theory. I am sure that he will not contend that everywhere, where oysters and other lamellibranchs "thrive," suspended sand is in greater volume than suspended diatoms. When it is not, do oysters select sand, and reject diatoms that are suitable for food? They must do the one thing or the other, or both, if sand is always to be more abundant than diatoms in their stomachs. It is difficult to understand how statements of this sort can so easily and confidently be made, and this one indicates how limited have been Professor Grave's studies on the stomach contents of oysters, to say nothing of those of other lamellibranchs. My own study of this subject has not been extensive, either, but I have material on hand to disprove this statement, if it is applied to the group of lamellibranchs in general. My "theory," that has been attacked, does not apply to the oyster alone, but to all lamellibranchs, most of which demonstrate it more clearly than the oyster does.

What may be called the argument of Professor Grave concerning the supposed reversal of the cilia beat on the palp tracts, with results that he makes no pretence of having observed, and has not formulated in his own mind, is based on the statement of Engelmann that he has actually witnessed this reversal on the palps of lamellibranchs, and on the facts that a reversal occurs in *Stentor* and other protozoa, and in *Metridium,* resulting in the selection of food and in the rejection of other particles.

I do not feel that I am in a position to object that even one who has never studied the matter himself should, without any question or hesitation, accept the statement of Engelmann and reject my own, on the matter of cilia reversal on the lamellibranch palp. "Why then," asks Professor Grave, after quoting Engelmann, "if a reversal of cilia and selection of food takes place in lamellibranchs, did Dr. Kellogg fail to see the reversal process?" The matter is settled at once; but I venture to suggest that somebody else should examine the palps of *Schizotherus,* of some species of *Cardium,* and of some other lamellibranchs in which the palp folds are large, to see what he can find. Let him be warned that he has no simple task, to be decided by a few observations. The turmoil on the palp face is so extraordinarily confusing that it seems just possible that even Engelmann may have been mistaken. I have supposed that I also have seen a reversal of the cilia beat on the palp, but many years ago concluded that I was mistaken. It is entirely possible that my present belief is erroneous, but I would prefer to be corrected by some one who has at least made an effort to study a few lamellibranchs, instead of studying papers. That protozoa reverse the cilia beat adaptively in food selection is suggestive in this case; but protozoa are not lamellibranchs, and I had hoped that the argument from analogy had been aban-

doned by biologists, especially in cases in which there was no possible excuse for it.

Professor Grave has fortified himself against confirmation of my views by assuming the position that even if no reversal of the beat of cilia is to be observed when my methods are employed, "it seems clear that it was due to the fact that the animals on which he made his observations were, in every case, in a mutilated condition." I removed the shell, "and," he says, "in its removal the adductor muscle was cut and the visceral ganglion, which is imbedded in this muscle, was necessarily severely injured. Under such a condition of shock normal behavior is not to be expected, especially in the case of activities that may be subject to nervous control."

Here is another pure assumption, made without observation, or even the opinion of some one else to substantiate it. I have no reason to believe that there is any element of truth in it; and I have several reasons for believing that it is not true that cilia of the palp, gill or mantle tracts are in any way under the control of the nervous system (such as the continued and unchanged beat on fragments of any of these organs, and also on isolated single cells, facts that can not be presented here).

Now the action of gill and mantle cilia are precisely the same in normal and in "mutilated" *Pectens,* and in some other lamellibranchs that open the shell valves widely, a condition that I have observed very many times. Why should Professor Grave not naturally expect these cilia tracts, as well as those of the palps, to behave abnormally from the detachment of the end of the adductor muscle? For he must know that gills and mantle receive large nerve trunks from the visceral ganglion, while the palps do not. The palps are so situated that they can not be examined without removing the shell valve, or using great force to pry the valves far apart by stretching the adductor muscles, and I have not seen their currents otherwise. I would like to ask Professor Grave if Engelmann was careful not to mutilate the lamellibranch on the palp of which he discovered a reversal of the cilia beat?

Finally, the cause of my mistakes in observation, we are told, was that when the end of the adductor muscle was separated from its shell attachment, the visceral ganglion "was necessarily injured." I venture to offer the information that, when one actually tries the experiment, it will be found that a shell valve may quite easily be removed from any lamellibranch without touching the visceral ganglion, or any of the nerves arising from it; and that to say that it is necessarily injured in the process is but to add another to the list of these entirely unsupported assumptions. This *a priori* method of arriving at truth ought to be even more out of place in present-day biology than the employment of analogies. Very likely, the use of the binocular dissecting microscope, which I did not have because it was not yet invented, will show that I made mistakes; but years were spent in making the observations before they were published, and perhaps I may be pardoned for objecting to their summary dismissal, in some cases with a very small show of reason, and in others with none at all.

JAMES L. KELLOGG

WILLIAMS COLLEGE,
WILLIAMSTOWN, MASS.

CHLOROSIS OF PINEAPPLES INDUCED BY MANGANESE AND CARBONATE OF LIME

IT has been recently found by M. O. Johnson at the Hawaiian Experiment Station that the chlorosis of pineapples occurring on highly manganiferous soils can be cured by spraying the leaves with ferrous sulphate.[1] As the chlorosis of pineapples growing on strongly calcareous soils in Porto Rico can also be cured by the application of iron salts, some have the idea that the two forms of chlorosis are the same. Although the phenomena are remarkably similar in many respects, and although the cure is the same, it is not yet clear that they are identical. It seems advisable to point out certain differences that seem to exist in the two kinds of chlorosis.

[1] *The Pacific Commercial Advertiser,* Honolulu, Hawaii, July 21, 1916, and a personal communication.

The chlorotic pineapples in Hawaii occur on acid or neutral soils that average 5.0 per cent. Mn_3O_4 and 0.5 per cent. CaO.[2] The chlorotic pineapples in Porto Rico occur on soils containing from 2 to 80 per cent. carbonate of lime and no manganese. That the chlorosis in Porto Rico is induced by the carbonate of lime was proved by direct experiment. Soils which normally produced healthy pineapples were made to produce chlorotic plants by the admixture of carbonate of lime from different sources.[3] We may thus speak of one as a manganese-induced chlorosis and the other as a lime-induced chlorosis.

The lime chlorosis was shown to be due to a lack of iron in the plant, caused by the carbonate of lime diminishing the availability of iron in the soil. At first it was not known whether the chlorosis was due merely to a lack of iron or to a lack of iron combined with a large amount of lime in the plant. Recent work seems to show that it is merely due to a lack of iron.

Now the manganese chlorosis may be similar to the lime chlorosis if the manganese acts similarly in merely diminishing the availability of iron in the soil. The recent discovery of Johnson shows that this may be possible. Previous work by Kelley,[4] and Wilcox and Kelley[5] suggests, however, that the manganese chlorosis may be more complicated. In the work of these investigators there is some evidence of a direct toxic effect of the manganese, although they do not ascribe the chlorosis to this. It is possible that the manganese chlorosis is due to a deficiency of iron combined with a direct toxic effect of the manganese. From the results so far obtained it can not be said whether the two kinds of chlorosis are essentially the same. Certain differences in the appearance and behavior of pineapples affected with manganese and lime chlorosis give reason for supposing the two forms may be more or less distinct.

The manganese plants are described as having roots with swollen tips and a generally poor root system, while the lime plants have good root systems, differing from normal plants only in the roots being longer.

In the development of "manganese yellows" a purplish color is spoken of as preceding the yellowish-white. This purplish color was not observed in the lime-induced chlorosis, although leaves sometimes had red splotches.

The manganese chlorosis is described as being most intense during the winter months when we may assume normal plants were growing less rapidly. The lime-induced chlorosis we found to develop fastest in plants growing most rapidly and to be more intense the more sunlight they received.

The application of ferrous sulphate to the leaves apparently has a more permanent effect on the manganese plants than on the lime plants. From the reports so far it appears that a few sprayings permanently cure the "manganese yellows," while application of iron salts to pineapples, rice, or sugar cane affected with lime-induced chlorosis effects only a temporary cure. Repeated trials showed that the treatment must be made frequently to maintain the plants in a green and vigorous condition. With rice growing on a strongly calcareous soil it was necessary to spray sixteen times with ferrous sulphate to maintain a normal growth. This difference in the amount of treatment necessary to cure the two forms of chlorosis may merely indicate a difference in the extent to which manganese and carbonate of lime depress the availability of iron.

The differences pointed out lend ground for supposing that manganese chlorosis may be due in part to a deficiency of iron in the plant, induced by the action of manganese in the plant or in the soil, and in part to a direct toxic action of the manganese. Lime-induced merely the result of a lack of iron in the plant, due to carbonate of lime diminishing the availability of iron in the soil. It is of

[2] Kelley, W. P., Hawaii Agr. Exp. Sta. Press Bull. No. 23.

[3] Gile, P. L., Porto Rico Agr. Exp. Sta. Bull. No. 11, 1911.

[4] Kelley, W. P., Hawaii Agr. Exp. Sta. Bull. No. 26, 1912.

[5] Wilcox, E. V., and Kelley, W. P., Hawaii Agr. Exp. Sta. Bull. No. 28, 1912.

course possible that the two kinds of chlorosis may be found to be essentially the same except for certain secondary effects produced by an undue absorption of manganese.

P. L. GILE

PORTO RICO AGR. EXP. STA.,
MAYAGUEZ, PORTO RICO

RELATIVE IMPORTANCE OF FUNGI AND BACTERIA IN SOIL

TO THE EDITOR OF SCIENCE: In a recent number of SCIENCE,[1] Waksman discusses the question: "Do Fungi Live and Produce Mycelium in Soil?" He answers the question in the affirmative. I have been interested in the same question for some time and have arrived at conclusions slightly different from those to be inferred from Waksman's article.

Waksman has tested for the presence of mycelium by placing a lump of soil about 1 cm. in diameter in the center of a plate of agar (containing Czapek's solution[2] for nutrient material). After 24 hours at 20–22° C., he finds that mold hyphæ radiate out into the medium from this lump of soil. If instead of soil he uses a drop of water in which mold spores are suspended, the amount of mycelium produced in 24 hours is very much smaller. From these findings he concludes that such a lump of soil contains living mycelium.

This conclusion is undoubtedly supported by theoretical considerations. The soil is continually showered with mold conidia from the air and without question contains moisture enough to allow them to germinate even if conditions are not favorable for their long-continued growth. The presence of mushrooms, moreover, in woodland soil and even in fields and lawns, proves beyond doubt that conditions do favor the growth of certain Basidiomycetes, at least. Their mycelium undoubtedly penetrates the soil sufficiently to be present in a lump as large as that used by Waksman. The question of real importance, however, is whether the mycelium is abundant enough in the soil to compare in its activities with the soil bacteria. Waksman does not discuss this question; although from his statement that the plate method gives figures as high as 1,000,000 fungi per gram soil, the natural implication is that they must be nearly as important as bacteria. His actual data, however, show nothing of the sort. He merely shows that mold hyphæ can be found in lumps of soil 1 cm. in diameter. A lump of soil that size contains many millions of bacteria. Compared to their activities, those of a few mold hyphæ would be quite insignificant.

I have tested several soils by Waksman's method, and have generally obtained results similar to his; but because the information furnished by it is not quantitative, I have modified the method by the use of smaller quantities of soil (crumbs weighing about 10 mg.), with quite different results. Such a crumb of soil should contain, according to the plate method—which is generally acknowledged to give figures that are much too low—perhaps 100,000 bacteria. If fungi are of anything like the same importance as bacteria in soil, one of these crumbs should certainly contain mold hyphæ. Their presence, however, has been indicated only in the case of soil to which large amounts of organic matter (manure or grass roots) have been added. When crumbs of soil to which no organic matter has been added have been used, the development of mold hyphæ in the agar has been slower than in the case of drops of water containing nothing but mold conidia. This certainly suggests that no mycelium is present in these small crumbs and that molds are relatively insignificant in soil; but as the crumbs of soil were always surrounded at the end of 24 hours by vigorously growing bacteria, it is possible that the development of mold hyphæ may have been suppressed. For this reason, Waksman's method is considered inconclusive.

It seems as if the question could be conclusively answered only by the use of a microscope. The microscope would furnish direct instead of presumptive evidence on the sub-

[1] SCIENCE, N. S., 44, pp. 320–322.

[2] Waksman does not publish the formula of this solution, but it has been obtained from him in a personal letter. It is: $MgSO_4$ 0.5 g., K_2HPO_4 1 g., KCl 0.5 g., $FeSO_4$ 0.01 g., $NaNO_3$ 2 g., Sucrose 30 g., to one liter of water.

ject. The reason no one has ever used a microscope in answering this and similar questions is undoubtedly because it is difficult to distinguish soil microorganisms without staining, and hard to stain them without staining the dead organic matter of the soil so deeply as to obscure the microorganisms. I have been struggling with these difficulties for the last two years and have at last found a method of staining that shows up the microorganisms of the soil without staining the soil particles or the dead organic matter. The details of the method are not yet ready for publication, but will be in a couple of months. Even though the technic is not yet perfected, it has furnished information that helps answer the question discussed by Waksman.

Briefly stated, every kind of soil microorganism except mold hyphæ has been revealed. Bacteria are shown in large numbers. So are Actinomyces conidia; while masses of Actinomyces hyphæ have been observed. Algæ are not uncommon, and objects resembling mold conidia have been found. Some organisms have been observed that are strongly suggestive of protozoa. But of mold hyphæ only an occasional small fragment has been seen, even in soil rich in organic matter. I realize that this microscopic method may, for some unknown reason, fail to reveal mold hyphæ even when they are present; but it is at least a direct method, while Waksman's method is indirect.

Although Waksman was presumably correct in his statement that fungus mycelium is present in soil, it is doubtful whether it exists there to a significant extent. Of course fungi live in soil, particularly when large amounts of organic matter are present; but it is hardly fair to compare their activities with those of bacteria—as has often been done in the past, either directly or by implication—until it is shown that their mycelium is present in soil in sufficient quantities to compare with the large numbers of bacteria that are known to be present in active form.

H. Joel Conn

New York Agricultural Experiment Station, Geneva, N. Y.

THE SUDDEN APPEARANCE OF GREAT NUMBERS OF FRESH-WATER MEDUSÆ IN A KENTUCKY CREEK

On the morning of September 27, 1916, there was brought to me a large bottle of creek water in which were the badly decomposed remains of several small gelatinous bodies which to my great surprise were recognized as parts of medusæ. They proved to have come from Benson Creek near Frankfort, about twenty-eight miles from Lexington, and had been alive, it was reported, the preceding evening. The bottle of water containing them had been brought to Lexington by Mr. Ben Marshall of the revenue service, at whose Frankfort office it had been left by Mr. C. M. Bridgemord. The latter was said to have asserted that he saw "millions" of the animals in the water. There was reason for some doubt about the "millions," but the evidence of the decomposed bodies showed that there were some in the creek and I could not rest satisfied without examining the locality for myself. With Mr. Marshall I left Lexington in the afternoon and arrived at his office in Frankfort about 4 o'clock P.M., where we found Mr. Bridgemord and Mr. J. L. Cox of the office, who is an ardent angler and had become interested in the animals. These gentlemen very kindly took me in a motor-boat down Kentucky River, and a short distance below the L. & N. R. R. bridge we turned into the mouth of Benson Creek and proceeded up the stream. Kentucky River has been dammed below this point, so that the water is backed into the lower park of the creek, producing a rather narrow, deep body of water with but little current. We traveled up this backwater for about a half mile, when we reached the point where the medusæ had been captured. The water looked rather bad and unsuited to them at first, but became better farther up, though still not very clear and with its surface roughened by a slight wind. The water was quite warm.

As soon as we reached the part of the stream where the medusæ had been found we began to strain our eyes, attempting to get a glimpse of one in the murky water. Very soon one was seen, a floating, pulsating gray

object, a few inches below the surface, looking so much like a bit of rubbish that it would certainly not have been recognized had we not been looking for it. Then several were seen near each other, then a few scattered individuals, which were all carefully taken into bottles, or with a small collecting net. Finally in the center of the stream we encountered them in numbers and from that time until it began to get too dark to see well, the boat was generally surrounded by them. There were four people in the boat filling bottles and jars rapidly and in a few minutes we gathered some scores. Often with a single movement of the net I captured several and before taking it in had secured a half dozen or more. Dozens were in sight at one time, and it was soon evident that Mr. Bridgemord was right, and that in truth there were millions of these medusæ in the stream. I have worked on the aquatic animals of Kentucky waters for many years and was not prepared to believe that medusæ would ever be found within the state in such numbers, nor indeed in any fresh water of the United States. Several hundred living individuals were brought back to Lexington with me, and some of them were alive until the afternoon of September 28. One by one they died in our city water, though it was kept running slowly through the aquarium in which they were confined. The temperature may have been too low or the water otherwise unsuited to them. A good many were fixed with corrosive sublimate and preserved, so it may be possible to study them fully and determine something of their relationships.

Like others of their kind they are hyalin, excepting the flap-like yellow reproductive bodies attached to the four radial canals close to the stomach. The umbrella-shaped body is widely convex, the depth (in life) being perhaps one third the diameter. It measures from about 14 to 15 millimeters across. The manubrium is prismatic and extends downward to the level of the outer margin of the umbrella; the mouth is surrounded by an eight-lobed rosette. At the margin of the umbrella are four long tentacles (perradial), measuring about 14 millimeters, which are attached a short distance above the margin, and in life are disposed to extend upward. Secondary more slender tentacles are about half the length of these large ones and are also attached above the margin; then still nearer the margin are numerous minute tentacles thickly crowded at their bases.

Where this multitude of medusæ came from is a mystery. Mr. Bridgemord, who first saw them, has fished in the stream for a good many years, but never saw one until September 26. I myself have several times examined the upper part of the creek rather carefully in search of *Simulium* larvæ, and while Polyzoa (a *Plumatella*) were abundant on the rocks, nothing resembling a hydroid was present in the water. My examinations were made some years ago, however. The hydroid generation in the stream ought to be easily discovered if the myriads of medusæ are any indication as to its abundance. I have not yet had an opportunity to search for this stage, but expect to do so at once.

Of the three genera to which fresh-water medusæ have been assigned, the Kentucky species belongs unquestionably to *Craspedacusta*. Dr. Mayer[1] describes *C. sowerbyi*, first discovered in a lily tank in Regent's Park, London, and later found in other parts of the world, as 12 millimeters wide. The Kentucky examples are somewhat wider, but in other respects agree closely with Dr. Mayer's description, excepting in the length of the manubrium, which he says extends half its length beyond the velar opening, whereas in Kentucky examples it reaches to about the level of the bell margin. In this respect the latter agree with the *C. kawaii*, described by Oka[2] from the Yang-tse-kiang River, China, but differ again and agree with *C. sowerbyi* in having but three ranks of marginal tentacles instead of seven. Dr. Mayer[3] thinks the Chinese species may be an exceptionally flourishing form of *C. sowerbyi*. The Kentucky examples are still nearer the medusæ described from Regent's Park. *Thaumantias lacustris* from a fresh-water lagoon in Trinidad is very

1 "Medusæ of the World," 1910.

2 "Annotationes Zoologicæ," Vol. 6, 1907.

3 *Loc. cit.*

different, being only from 2 to 2.5 mm. in diameter, the bell provided with 16 to 24 long tentacles with basal bulbs. The American *Microhydra ryderi*[4] is only 0.4 mm. in diameter. It may be the young medusa of *Craspedacusta,* but shows some differences from young *C. sowerbyi. Limnocida tanganyicæ* Gunther, from Lake Tanganyika, Central Africa, has the gonads attached to the stomach, and differs otherwise.

Everything considered, it seems best for the present to regard the Kentucky medusæ as a form of *C. sowerbyi.*

Harrison Garman
Department of Entomology and Zoology,
University of Kentucky

SCIENTIFIC BOOKS

With Scott: The Silver Lining. By Griffith Taylor, D.Sc. With nearly 200 illustrations and maps. New York: Dodd, Mead and Co. Pp. xiv + 454. $5.00 net.

Few volumes on polar exploration have been written so attractively as to the phases treated. The author has placed the reader in possession of the environment, wherein his own experiences are largely subordinated to the story, both of the incidents of antarctic research and also to the aspects of polar nature and its scanty fauna. The style is delightfully human, and is often brightened by humor. Indeed it admirably presents the silver lining of Scott's tragic expedition.

The biologist, the geologist and other scientists will find much information along lines usually ignored by polar authors, who are inclined to adhere closely to their specialties, and in technical fashion. These data are most welcome as the detailed memoirs, on the very extensive and most varied scientific researches of Scott's expedition, will not be completed for several years, though ample funds have been provided for their publication.

Botanists will be interested in the discovery of considerable patches of moss, on the east coast of Victoria Land, on which all the field work of Taylor was done—in two journeys. Taylor says:

> I was amazed to see a carpet of green moss, as flourishing as any in more temperate regions—three types of vegetation were present. One was the moss, to my unbotanical eyes, of universal distribution. The other two species may have been algæ, one resembled the sea-weed called *Ulva.* The patch of green was 60 feet long and about 15 wide—possibly the largest area of vegetation south of 77°.5.

Sea-kale planted in the open air sprouted but did not develop.

Insects were found, the antarctic *spring-tail,* of which the record says. They were found

> clustering among the whitish roots or hyphæ of the moss. They would be frozen stiff in a thin film of ice until one turned the stone into the sun. Then the ice would melt and they would move sluggishly about until the sun left them. I can not imagine a finer example of hibernation.

There were two species, one red and the other the millimeter-long blue, both unknown.

Of the antarctic sea—noted on the voyages to and fro—the author writes:

> Microscopic life simply swarms in these polar seas, to an infinitely greater extent than in the warmer waters of the tropics, though one would be inclined to the opposite belief. . . . There is almost as much protoplasm per acre of ocean as there is in a well-cultivated crop on land. The description of the cycle of life is interesting, to a layman at least—from plankton to whale-killers.

Meteorologists will find data as to blizzards, etc., which are much less violent on the shores of Ross Sea than those reported by Mawson from Adelie Land. The record with Scott was that of July 12, 1911, when the maximum wind was 70 miles per hour, with a maximum temperature of 8°. The comparative mean temperatures for the years 1902–03 and 1911, were respectively as follows: (approximately) January, 24° and 22°; February, 13° and 15°; March, 4° and 8°; April, —8° and —2°; May, —14° and —12°; June, —15° and —14°; July, —16° and —22°; August, —17° and —23°; September, —15° and —17°; October, —7° and —2°; November, 13° and 13°; December, —23° and —21°. The minimum temperature mentioned is that of —77° experienced by Cherry in his visit to

[4] Potts, Science, Vol. 5, 1885.

Cape Crozier for the purpose of obtaining eggs of the emperor penguin.

Naturally the most extensive data pertain to geological subjects relative to west Victoria Land, which was twice visited and explored by Taylor, under conditions of extreme hardship which tested the strength and endurance of the party to the utmost. Taylor's line of research specially pertained to the "effect of ice in carving out the features of the earth's surface." Near two great glaciers he noted:

> The grandest geological section I have ever seen. It was capped by yellowish rock, which represents the most eastern exposure of the Beacon sandstone in the valley. Beneath this were two *sills* of dolorite . . . which represented flows of lava wedged in between the granites and sandstones. . . . Above and below the lower of these black sills were layers of gray granite.

Considerable attention is given to descriptions of cwm, or arm-chair, valleys. At one point was discovered a huge deposit of mirabilite (sodium sulphate) about 10 by 50 feet in surface area.

The seaward movement of the antarctic glaciers engaged Taylor's attention, and careful measurements were made of several. During the ten coldest months one moved about twenty feet. The Tongue on the east coast of Victoria Land was moving seaward about a yard a day in January—midsummer.

The vitally important fossils of the expedition are those obtained by Scott at the head of Beardmore glacier—in my opinion elsewhere expressed, obtained and preserved at the cost of the lives of that heroic explorer and his sledge comrades—which are considered as epoch-making in antarctic geological history. Among these, it may be recalled, was a fern-like *Glossopteris,* a plant of the Permo-Carboniferous age. Other fossils of the Cambrian age had been brought back by Shackleton from the Beardmore glacier, in 84° S., among which were specimens of one fossil which united the character of the sponges and corals.

Taylor's party—Debenham, Gran and Taylor—contributed specimens of fossils of the armor-plate of a primitive fish. They are thought to pertain to the Devonian age, and so are intermediate between the antarctic fossils of the Cambrian limestones and the Permian coal-measures.

One must read the book itself to obtain any adequate idea of the hardships and privations endured by Taylor, Debenham and Gran in their geological researches on Victoria Land. They were accepted as part of the *game,* and with such a spirit of comradeship and solidarity as alleviated the inevitable miseries of field life in the polar regions. This fine spirit is indirectly exhibited by Taylor at the end of his story, where he says:

> Only in polar lands is to be found the joy of a *real return to the primitive,* in association with the best types of strenuous youth. There, if anywhere, is life worth while.

A. W. GREELY

Rhynchophora or Weevils of Northeastern America. By W. S. BLATCHLEY and C. W. LENG. The Nature Publishing Co., Indianapolis. Pp. 682. Price $4.00.

When, in 1910, the senior author, Mr. Blatchley, published his notable work on the Coleoptera of Indiana, the Rhynchophora were not included. We had, however, the assurance of the author that a further paper covering this group would be forthcoming. In the appearance of the present volume, the promise of six years ago is more than fulfilled, for we have here not merely a complement to the Coleoptera of Indiana, but a review of much wider usefulness, covering as it does the entire country east of the Mississippi River.

Although the Rhynchophora or Weevils—the latter term used in the entomological rather than in the popular sense—constitutes only about twelve or fifteen per cent. of the Coleopterous fauna of the country, still the number of species is very large—no less than 1,084 being recognized by the authors from the territory named, these being distributed among nearly 300 genera. The only previous work on North American Rhynchophora with which the present one can be compared is that published by Le Conte and Horn in 1876. This Coleopterological classic, although still of the greatest value as the basis of our modern classification, is altogether inadequate as a student's handbook, the number of species

given from the whole United States being less than two thirds of that now known from east of the Mississippi.

As expressed by the authors, the primary object of the present manual is—as in the "Beetles of Indiana"—"to furnish to students and tyros in entomology a simple means of enabling them in the most direct way possible to arrange, classify and determine the scientific names of the weevils in their collections." To do this, all the higher subdivisions have been carefully defined, keys for the separation of all families, tribes, genera and species have been prepared or adapted, original descriptions have been condensed so as to show more readily the principal diagnostic characters, and geographical range, time of appearance and habits recorded so far as known. The whole is preceded by a chapter on structural characters, and followed by a tolerably complete bibliography and indexes of both the beetles and the plants on which they occur. Add to this the fact that the press work leaves little to be desired and the illustrations are numerous, nearly all good, and many of them beautiful, and we have a very attractive as well as useful contribution to Coleopterology.

In a work of this sort, based upon a multiplicity of sources of information, it is inevitable that there should be some errors of fact; furthermore inasmuch as all schemes of classification and taxonomy involve so large an element of individual opinion, it is altogether unlikely that any specialist could be found who would agree entirely with the authors in their sequence of tribes, genera, etc., or in their delimitation of species. The authors, on the whole, appear to have followed a sanely conservative course, and, while the work embodies the results of the best of recent studies both in this country and in Europe, they have rarely accepted the views of the extremists, and, where differing from the authorities, have frankly stated the reasons for their conclusions.

Let no one be deceived by the words of the authors, quoted above, into believing that the book will prove a sinecure for the entomological "tyro." A difficult subject has perhaps been simplified as far as possible, but it still remains a difficult subject, and the tyro will still have to depend largely on the specialist for the determination of his specimens. On the other hand, the student with a considerable fund of experience will find this work of very great assistance. Would that we had more like it.

H. C. Fall

Pasadena, Calif.

SCIENTIFIC JOURNALS AND ARTICLES

Bollettino di Bibliografia e Storia delle Scienze Matematiche. Publicato per cura di Gino Loria. Torino, 1915, 1916.

Such are the conditions in Europe at the present time that both the publication and the transmission of scientific journals are attended with great difficulty. Some of these journals have been discontinued altogether, others appear in reduced form, and many are greatly delayed if, indeed, they are allowed to pass the barriers at all. Of those which reach us Professor Loria's "Bollettino" is among the most regular and among those which best preserve their usual placidity.

Since this publication consists chiefly of notes on recent mathematical works, there are but few articles that admit of interesting summary in a review of this nature. It is pleasant to observe, however, how little the war disturbs the academic atmosphere, for these mathematical notes, relating to current books of various European belligerents, give no evidence whatever of the conflict which now disturbs the world. Such, for example, are the "notizie" on "La matematica in Germania in questo ultimo quarto di secolo," "Sofia Germain" (by Schwarz), the "Materialien für eine wissenschaftliche Biographie von Gauss" (Klein and Brendel), and the "Entwickelung der Mengenlehre und ihrer Anwendungen" (Schoenfliess).

Of the original articles of a mathematico-historical nature, mention should be made of a few which may have some interest to American readers. M. Lucien Godeaux of Liège has an article on "Un mathématicien Belge du XVIième Siècle: Jean Taisnier." Al-

though Quételet mentions this writer in his "Histoire des sciences mathématiques et physiques chez les Belges," and Jules Dewert and Modeste Soons have recently written upon his work, he is practically unknown to English and American mathematicians. Born in 1508, dying probably about 1562, he claims to have been a professor of mathematics in Rome in 1546, and he certainly held such a chair in Ferrara in 1548. His works, eleven in number, relate chiefly to the use of the sphere and the annulus, although some were purely astrological in their contents. One of his books was translated into English under the title "A Booke concerning navigation, translated into English by Richard Eden," London, n.d. Like most of the secondary writers of his time, he plagiarized freely from the works of others, but his "De annuli sphaerici fabrica & usa" (Palermo, 1550) shows not a little originality.

Professor J. H. Graf, of Berne, whose contributions to the history of mathematics in Switzerland are well known, has a series of articles on "La correspondence entre Ludwig Schläfli et des methématiciens Italiens de son epoque." This is a suitable sequence to Professor Graf's earlier articles on the correspondence between Schläfli and Jakob Steiner and between Schläfli and Cayley.

Professor G. Vivanti has an interesting note on Luigi Forni, a Pavian mathematician (1780–1856), whose Nuove Ricerche (Pavia, 1811) is not without merit. There are biographical articles of some length on Luciano Orlando (1877–1915), a prolific writer, and Ruggiero Torelli (1884–1915), a worthy contributor to modern higher algebra and the theory of curves. The numerous reviews by Professor Loria himself are of special interest.

DAVID EUGENE SMITH
COLUMBIA UNIVERSITY

"THE AMERICAN MINERALOGIST"

The American Mineralogist is a new magazine, devoted to the interests of the scientific mineralogist, the student of mineralogy, curators of museums, and collectors of minerals.

It is a successor to *The Mineral Collector*, founded in 1885 and discontinued in 1909; and appropriately, the first article in the new magazine consists of an appreciation of the contributions of Arthur Chamberlain, publisher of *The Mineral Collector*. Other articles in the first number treat of lamellar calcite, columnar manganocalcite, the chemical elements; and the reports of the meetings of the New York and Philadelphia Mineralogical Clubs are given. The magazine reviews abstract articles on mineralogical subjects, so as to make the work being done in this science available to those who do not have access to the more technical journals.

The second number is devoted to an account of the wonderful gem minerals of Madagascar. In the third number is an article on glauberite crystal-cavities, in which the methods used in interpreting these curious "holes" in certain geological formations are described. Stevensite, an alteration product of pectolite from New Jersey, is shown to deserve recognition as a definite mineral species by Mr. M. L. Glenn. A poem, called "The Physico-chemical View," a satire on the mannerisms of several Washington scientists, is included.

The Exchange Column of *The American Mineralogist* is an excellent feature and one that will interest every private collector or curator of a museum who may wish to dispose of his duplicate material for some specimens in which his collection is lacking. Thus both parties are benefited, and the various mineralogical dealers will keep those informed who are in need of such materials.

The American Mineralogist is edited by Wallace Goold Levison, and the associate editors are Edgar T. Wherry, of the U. S. National Museum; Samuel G. Gordon, of the Academy of Natural Sciences, Philadelphia, Pa., and W. Scott Lewis, of the Krotona Institute, Los Angeles, California. The magazine is octavo in size, and the numbers already issued have given sufficient assurance that the typography will continue to be excellent. As this special field has never before been covered, the journal should meet with considerable encouragement and success. G. F. K.

NITRATE DEPOSITS IN THE UNITED STATES

A PRESS bulletin of the U. S. Geological Survey states that nitrate deposits in many parts of the United States have been examined during the last two years by the survey. The importance of finding a natural supply of nitrates within our own borders has given incentive to this work and has directed widespread public attention to the subject.

Prospectors in many places have raised great hopes by finding good surface showings of these salts, but investigation has seemed to force the acceptance of a general adverse judgment as to their value—a judgment that has been adopted with the greatest reluctance by all concerned. Incidentally, advantage seems to have been taken of the situation to promote certain stock-selling enterprises, even after the evidence as to the worthlessness of the deposits became sufficient to satisfy any competent judge, so that one is forced to question either the good faith of the promoters or their practical judgment.

As a result of careful study of these deposits, and particularly of evidence gathered on recent visits to prospects in different parts of the country, Mr. Hoyt S. Gale, a geologist of the Federal Survey, has submitted the following general summary, which is commended to the consideration of those who are tempted to invest their money in such enterprises.

Fine specimens of practically pure nitrate of soda and nitrate of potash (saltpeter) have been found in many parts of the country, and careful investigation of specimens and localities seems to warrant some definite conclusions as to the practical value of these deposits, especially to those who are invited to spend their money in investigations like those the survey has already made.

The nitrate salts occur as crusts or films on the faces of ledges; as seams—most of them thin, though some are fairly thick—in crevices of shattered rock; and as deposits filling spaces in porous rocks at and near the surface or extending to a depth of several feet. They are naturally preserved in recesses in the rock ledges, where they are sheltered from the dissolving action of rain, snow water, or even mist. They are found in lava ledges, in beds of volcanic tuff or ash, and in limestone and sandstone. Their existence or preservation is apparently dependent rather on the shattered or porous nature of the rock than on its kind or composition. These deposits, which have been referred to as cave or ledge deposits, are of essentially the same type wherever found, although they vary considerably in details of occurrence.

The incrustations are found not only on the faces and fractures of ledges of solid rock, but some of them form layers or cementing constituents in the loose soil and rock breccia at the bases of cliffs, or lie in places protected from the weather. Some samples obtained from both these sources are rich in nitrate salts, and analyses of such materials will bear little significant relation to the actual character or content of the mass of the rock of which the ledge is formed. It appears that the deposits are surficial—that is, they do not extend far into the mass of the rock—and the nitrate salt found is insignificant in amount.

Nitrates are found in unusually large quantities in some soils and in some clay hills, particularly in southern California. These deposits have been examined by many persons and the general conclusion reached has been unfavorable to the idea of their practical utilization. The nitrate content, although unusually large as compared with the content of ordinary soils, probably does not average over 1 or 2 per cent. of the soil or clay, and it is very doubtful whether the material could be worked commercially.

Any one who is not convinced by the judgment already reached as to these deposits and who is determined to devote his time or money to their further exploration should do so with full knowledge of the evidence already in hand and should not be led into such a venture by more or less misleading representations. The Geological Survey will always be glad to make an examination of any samples submitted.

AGRICULTURE OF THE HIDATSA INDIANS

A DOCTOR'S thesis of unusual practical value is that of Dr. Gilbert L. Wilson submitted in

June to the faculty of the University of Minnesota for the degree of Ph.D. in anthropology.

With funds largely from the American Museum of Natural History, New York, research work has been prosecuted each summer since 1910 among the Hidatsa and Mandan Indians on the Mandan Reservation, North Dakota. So important have the findings of Mr. Wilson been for probable development of a drought-resistant maize for the farmers of the northwest that both Dean A. F. Woods, of the college of agriculture, University of Minnesota, and Mr. M. L. Wilson, of the Agriculture Experiment Station, Bozeman, Montana, have contributed toward the financial support of the research.

It is interesting to learn that in western North Dakota where maize has been a doubtful crop as grown by the white farmer, the Hidatsa and Mandan Indians have for centuries been successfully cultivating it. With crudest wooden and bone tools they developed an agriculture that in some respects surpassed that of most white farmers at present in that area.

Maize, sunflowers, beans, squashes and tobacco were raised by the Hidatsas, but their principal crop was maize. The chief varieties of maize were white and yellow flint, "sweet corn," and those producing white and yellow meal. Corn planting began when the wild gooseberry came to full leaf. The corn hills were prepared with digging-stick and bone-bladed hoe. The earth was raked over the seed and patted down with the hands. Each corn hill stood exactly where a hill had stood the year before. The fields were hoed twice during the summer. The second hoeing was accompanied by hilling up.

Corn was husked in the field. Friends and relatives commonly joined in a husking bee. Fine full ears were braided in strings; and from these strings, carefully dried, seed ears were chosen for the next year. A provident family kept two years' seed on hand, in order that the ill-favored grain of a poor year might not have to be sown. In the selection and preparation of seeds of all their cultivated crops, these Hidatsa Indians were far more careful than most of our American farmers. The braided strings of ears were transported from the field to the village on the backs of ponies. Smaller loose ears were borne in baskets on the backs of the women; these smaller ears made the main part of the harvest. Before each lodge stood a drying stage, a rather elaborate structure floored with planks split from cottonwood trees. On this floor the loose ears were spread to dry. The braided strings were hung on a railing above, and were bound closely in small bunches to prevent the wind from shelling the drying grain. When well dried the smaller ears were threshed or shelled, and this threshed grain and the braided ears were stored and sealed in jug-shaped caches or pits dug in the ground. Green corn, after having been boiled, shelled and dried, was stored in the caches in bags. Curiously, sweet corn, or "gummy corn" as the Indians call it, was never boiled green. It was prepared by parching, after having become thoroughly ripe.

Fallowing of fields was practised by the Hidatsa agriculturists, and they knew that wood ashes increased the yield of a field. When new ground was cleared the felled trees and bushes were spread over the field and burned for the sake of the ash.

While most of the field work was done by the women, the men assisted in part of the labors. They aided in clearing the fields, and did the heavy lifting when a stage was built. However, it was thought that a younger man was better employed hunting, or warring. But when the men's hunting and war days were over they thought it no shame to help their women plant and hoe. Field work was done in the early hours of the day, the women commonly rising with the sun, and returning to the village to eat and rest about ten o'clock in the forenoon.

Seed corn from the most intelligent and skilled of the Hidatsa women is being sold to northwest farmers by a commercial seed house. This fact and the breeding experiments by scientific experimenters bid fair to make another contribution to American economic life by the Indian.

The thesis is being printed by the University of Minnesota.

Albert Ernest Jenks

SPECIAL ARTICLES

THE CHEMICAL CONSTITUTION OF CHITIN[1]

The prevalent ideas concerning the molecular structure of chitin have been based upon the fact that it gives off acetic acid when acted upon by strong reagents, such as concentrated acid or alkali, and that its elementary composition suggests the empirical formula $C_8H_{15}NO_6$.[2] Since it is also known that chitin yields on decomposition glucosamin it was a logical inference that the above formula represents an acetylated glucosamin

$$\begin{array}{l} CH_2OH \\ CHOH_3 \\ CH—NH—CH_3CO \\ CHO \end{array}$$

of which chitin is the polymere.

This hypothesis regarding the structure of chitin has been strengthened by other observations, viz., that if chitin is dissolved in strong sulphuric acid, allowed to stand several days and then diluted with a large quantity of water, a white precipitate is formed which on analysis proves to be a monoacetylglucosamin. Occasionally, however, a substance is isolated which represents a monoacetyldiglucosamin.

An investigation upon chitin of lobsters which I conducted recently at the Woods Hole Fisheries Biological Laboratory brought out certain facts which indicate that, while the observations and analyses mentioned previously are doubtless correct, the hypothesis to which they gave origin is based largely upon misconception. I shall present here a brief outline of the principal results of the investigation, reserving a more detailed statement for publication in the near future.

It will not be necessary in this preliminary note to discuss the experimental procedure beyond the mere statement that pure chitin was hydrolyzed with varying strengths of sulphuric acid, and for varying lengths of time, the cleavage products as well as the volatile substances formed during hydrolysis having been quantitatively determined.

The results of fundamental significance yielded by this investigation are the following:

First. Very little volatile acid is formed in the early period of hydrolysis of chitin, though all its glucose molecules may already be split off. A very large production of volatile acid is invariably found when the sugar molecule itself is attacked by the acid medium.

Second. The volatile acid produced is not acetic only. At least in one experiment it was possible to show that two per cent. of the acid was formic. There is good reason for believing that other volatile acids, too, may be formed, but the attempt at isolating and identifying those has not yet succeeded.

Third. The maximum yield of sugar is about 81 per cent.

Fourth. The amino group is readily split off from the glucosamine. The hydrolyzed material contains the ammonium sulphate which can be distilled off directly by making it alkaline, and the ammonia can be collected in standard acid.

Fifth. The nitrogen of the amino group *does not represent the total nitrogen in the chitin molecule.* There is another nitrogenous part in the molecule which is characterized by great resistance, so that the nitrogen of that small fraction can be obtained only by digesting with concentrated sulphuric acid. There is a remarkably constant relation between this easily detachable nitrogen group and the stabile nitrogen fraction. In my experiments, the latter formed 12.04 to 12.45 per cent. of the total nitrogen.

The interpretation of these results is very obvious. The chitin molecule is certainly more complex than previously assumed. It may be regarded as consisting of two parts: one containing all the glucose and all the amino groups, the other being a stable nitrogenous compound which yields no glucose. It would be venturesome at this time to express an

[1] Published with the permission of the Commissioner of Fisheries.

[2] The formula actually computed from the analytical data is $C_8H_{14}NO_6$, but $C_8H_{13}NO_6$ is the one usually given because it corresponds to the hypothesis.

opinion as to the nature of the latter fraction. The efforts to isolate it for detailed study have not been successful thus far, but the work in this direction is continued.

The volatile acid given off, of which acetic is the more predominant constituent, does not represent a component part of the molecule. It is a decomposition by-product of the glucose. It is possible to lower greatly the yield of sugar by hydrolyzing chitin with strong acid or by raising the temperature or increasing the duration of the hydrolysis. A great evolution of volatile acid from the chitin will occur simultaneously. The very small quantity of acid formed even in the cold must be likewise attributed to the slow oxidative action of the strong sulphuric acid which must be used in order to dissolve the chitin.

Assuming that the empirical formula for chitin is correct (elementary analyses are in progress now to verify this) we may interpret the above facts in its light, without recourse to the hypothesis that the chitin molecule contains an acetyl group. If we assume that the chitin is a polymere of eight $C_6H_{15}NO_6$ molecules, this should yield on hydrolysis seven molecules of glucosamin, $C_6H_{13}NO_5$, one molecule of glucose, $C_6H_{12}O_6$, and one molecule of the yet unidentified nitrogenous fraction. As the amino groups are cleaved off in the hydrolysis, we get altogether eight glucose molecules to seven ammonia nitrogens and one residual nitrogen. Theoretically, then, the chitin molecule should yield 81.1 per cent. of glucose, and 87.5 per cent. of amino nitrogen and 12.5 per cent. of nitrogen in a stable combination. The facts obtained by hydrolysis agree remarkably with these theoretical expectations.

I could hardly enter here upon a discussion of the bearing of these results further than to say that monoacetylglucosamine, or for that matter monoacetyldiglucosamine, have no relation to chitin. They are secondary products, and are formed after the chitin molecule has been broken down by the action upon it of the sulphuric acid.

S. MORGULIS

THE CREIGHTON MEDICAL COLLEGE,
OMAHA, NEB.

OUTLIERS OF THE MAXVILLE LIMESTONE IN OHIO NORTH OF THE LICKING RIVER[1]

IT is well known to those familiar with Ohio geology that the Maxville limestone is the uppermost formation of the Mississippian System found in the Ohio scale, that its outcrop is limited in extent, patchy in character, and that the overlying Pennsylvanian beds rest upon it unconformably. Up to the present, all the known outcrops of this formation occur south of the Licking River in central Ohio and they lie in a belt ten or twelve miles wide, which extends from the above river on the north to the Ohio River on the south.

It has long been supposed that the formation once extended northward to northern Ohio and was removed by late Mississippian erosion. The supposition was based upon the presence of lime cobblestones more or less silicified which are found in places in the bottom of the Coal Measure basal conglomerate, and which were said to carry Mississippian fossils. Since no other Mississippian limestone was known to occur in the state, it was concluded the cobble stones must have been derived from the Maxville.

It is the purpose of the writer to (1) point out the northward extension of this limestone, to (2) throw further light on the origin of the cobble stones, and to (3) emphasize a reason for the absence of the limestone in northern Ohio.

Beginning at the Licking River various outcrops of this limestone were found as far as forty miles north of the city of Zanesville in a belt ten to twelve miles wide. They invariably occur in isolated patches, are unconformable with superjacent beds, vary in thickness from two to nine feet, and are clearly erosion remnants of a former continuous stratum. Where it is not weathered it presents the same blue-gray, fine-grained, compact character found far to the southward. In places it is fairly fossiliferous, and when fully weathered there remains a residual ocherous earth of deep yellow to chocolate color, mingled with silicious concretions. The latter weather

[1] Read before Section E, A. A. A. S., Columbus meeting, 1915.

nearly round, are usually yellowish to white in color, and generally carry fossils of coral, brachiopods, and bryozoans common to the limestone.

At many places between outcrops of the limestone occur beds of limestone cobbles which are more or less silicified and in all respects identical with those found in the disintegrating limestone. Furthermore, upon noting their elevations, these isolated beds of cobble stones are found to lie in the plane of the limestone—never above it, and only scattered or displaced cobble stones are found below the plane. These facts point unmistakably to the limestone as the source of the cobbles and bear evidence of the former presence of the limestone at all points where these beds occur.

Wherever the Mississippian-Pennsylvanian contact dips much below the plane of the Maxville limestone, little or no trace of the limestone was found. Where the contact is not far below this plane, silicified cobble stones are often found in the base of the Coal Measure basal conglomerate which are identical with the residual cobbles of the limestone. Within the belt considered the contact sometimes falls 100 feet or more below the Maxville plane and all such places have been found to be clearly defined valleys which trenched the Mississippian surface.

It is now known that the Maxville limestone is found two thirds of the distance across the state with strong probability of still further extent formerly.

The Berea sandstone, lying at or near the base of the Mississippian system, is an excellent datum plane. Using it for this purpose in the general direction of the Maxville outcrop, it is found that the Berea-Maxville interval increases northward. In Vinton County, in the southern part of the state, the interval between the top of the Berea and the top of the Maxville is about 650 feet; at Rushville, in the eastern Fairfield County, about 800 feet; at New Castle, in Coshocton County, about 840 feet; near Killbuck, in southern Holmes County, about 870 feet; and twenty miles north of the last point in central Wayne County east of Wooster a thickness of 900 feet of shale and sandstone above the Berea does not quite reach the Maxville horizon. Northward from Wayne County the total thickness of the Mississippian strata decreases notably, due to greater erosion in late Mississippian time. In northeastern Ohio the Pennsylvanian beds lie, commonly, only about three to four hundred feet above the Berea, and in the old Mississippian river valleys, so clearly defined in this area, the Sharon conglomerate sometimes lies but 100 feet above the Berea. These thicknesses are clearly far below the Maxville horizon.

Central Wayne County is about fifty miles from Cleveland and 150 from Portsmouth on the Ohio River, the region of the southern outcrops of the Maxville. If the plane of the Maxville be projected northward to Cleveland with the slowly increasing interval between it and the Berea, the Maxville would lie about 1,050 feet above the Berea.

In the light of these facts it is apparent that the Maxville will not be found in northern Ohio, and that outcrops may not be expected beyond northern Holmes, or central Wayne County.

It will be noted further that these figures reveal the interesting fact that the Mississippian system thickens northward, although thinnest in the north now as a result of erosion.

Mount Union College G. F. Lamb

A METHOD FOR MAINTAINING A CONSTANT VOLUME OF NUTRIENT SOLUTIONS

With plant experiments involving the use of various nutrient solutions it is important that there should be no undue loss of solution due to evaporation or the taking up of the solution by the plant, as it has been shown that an increase in concentration due to a loss of water by evaporation or transpiration may seriously impair results.

To save time in refilling the culture vessels to a constant volume the following simple method has been devised. It works automatically and keeps the solution at a constant level, and the only attention required is to refill the reservoir when empty.

A drawing will show the arrangement of the device, which consists of a flask or bottle of

any convenient shape fitted with a two-holed rubber stopper through which are inserted two glass tubes of 5 mm. bore, one projecting 5 cm. and the other 2.5 cm. from the stopper.

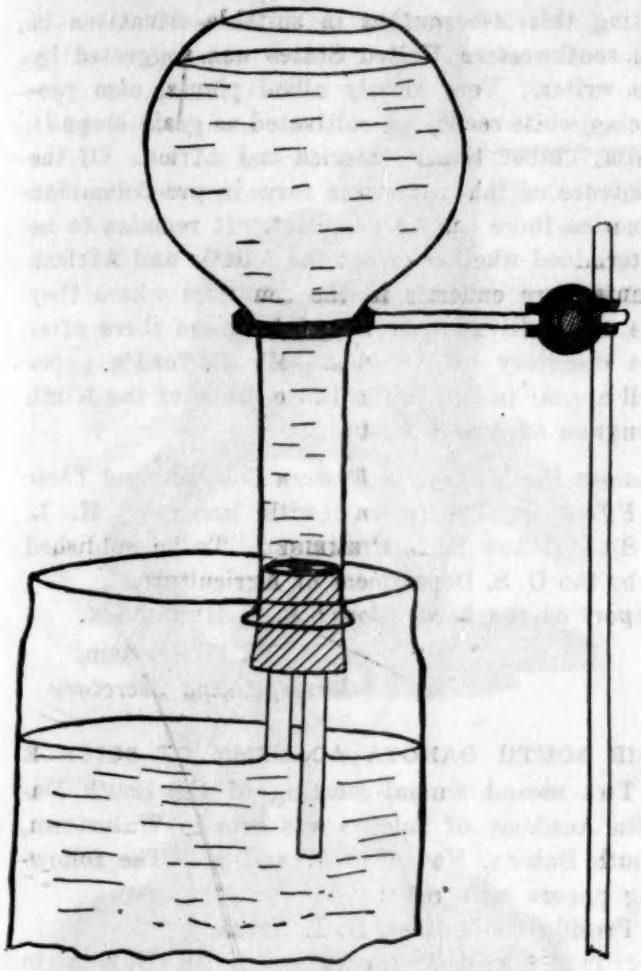

FIG. 1.

The operation of the apparatus is as follows: the flask is filled with the nutrient solution which is used in the culture jar and inverted above it (or the glass tubes can be bent so that the flask is above and at one side of the jar, and thus out of the way of the plants). The solution flows out of the longer tube, the shorter tube allowing the ingress of air. This flow of solution from the longer tube may be stopped by lowering the flask until the end of the shorter tube comes in contact with the solution in the culture jar, which seals the end of this tube and prevents the entrance of air and thus the exit of solution from the longer tube. The flask is adjusted so that the lower end of the shorter tube is at a level desired as the constant one, and as soon as the solution sinks (about 1.5 mm.) below this level either from evaporation or the taking up of the solution by the plant the air enters through the lower end of the shorter tube, allowing the exit of solution through the longer tube until the level of solution in the culture jar rises to the end of the shorter tube, which is sealed until the water level sinks again. In the case of culture experiments where the mouth of the culture jar is covered it is only necessary to bore two holes to admit the two tubes projecting from the reservoir.

ORTON L. CLARK
MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION

SOCIETIES AND ACADEMIES

THE BOTANICAL SOCIETY OF WASHINGTON

THE 112th regular meeting of the Botanical Society of Washington was held in the Assembly Hall of the Cosmos Club, Tuesday, April 4, 1916. Fifty-two members and five guests were present. Harry R. Fulton, George L. Keenan, Lester A. Round, J. F. Clevenger, C. E. Temple, A. E. Aldous, Victor Birckner and Forrest S. Holmes were elected to membership. The following papers were presented:

Botanical Explorations in South America: DR. J. N. ROSE.

Plants Domesticated in Peru: MR. O. F. COOK.

Mr. Cook gave a brief account of the agriculture of the Incas with their wonderful terraces and system of irrigation. Among the plants domesticated by them were maize, beans, lima beans, peanuts, quinoa (*Chenopodium quinoa*), red peppers (*Capsicum*), mandioca, tomatoes, passion fruits, sweet potatoes, tuberous *Tropæolum* and *Oxalis*, arracacha (a celery-like plant), squashes and pumpkins, gourds; and among the fruits, chirimoyas, lucumas and pepinos. The narcotic coca, from which cocaine is now prepared, was also grown. Mr. Cook's paper will be embodied in a forthcoming article in the *National Geographic Magazine* for May, 1916.

THE 113th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Tuesday, May 2, 1916. Mr. Frank N. Meyer, geographical explorer of the U. S. Department of Agriculture, was elected to membership. The program consisted of the following papers:

Dr. Edward L. Greene, an Appreciation: H. H. BARTLETT.

As it was impossible for Mr. Bartlett to be pres-

ent at the meeting, the paper was read by title. It appeared in full in *Torreya* for July, 1916.

Winter Rape and Adulterants of This Seed (with lantern): Edgar Brown.

Five types of plants raised from seed imported into the United States under the name of rape were briefly described and illustrated. The Dutch and German sources of the winter rape seed normally used in this country for the production of forage having been shut off, seed was imported from other sources, including winter rape from England, France and Japan, annuals of no forage value from Argentina, France, China and Japan, and biennials of no forage value from France and Japan.

An Economic Amaranthus of Ancient America (with exhibition of specimens and lantern): W. E. Safford.

Among the tributes paid to Montezuma by the pueblos of Mexico was a certain grain of ivory whiteness and more minute than a mustard seed, called by the Aztecs *huauhtli*. Eighteen imperial granaries were filled with it each year, each having a capacity of about 9,000 bushels. In some parts of Mexico, at times when maize was scarce, this seed was used in its stead and along the Pacific coast it was an important food staple. Cabeza de Vaca noticed it in Sonora in 1536. Its most important use was in religious ceremonies, when a paste, called *tzoalli*, was made of it together with maguey syrup, and images of the god Uitzilipuztli were molded of it. After having been adorned with beautiful ornaments and carried in procession, the image was carried to the top of the pyramidal temple in the city of Mexico. Sacrifices were made to it, including human beings, and the next day it was broken up into fragments and served as communion to the people. For a long time the botanical identity of this seed was unknown. The late Edward Palmer while making collections in the states of Sinaloa and Jalisco, found an *Amaranthus* growing both in cultivation and spontaneously. Its ivory-white seeds, resembling fish-eggs, corresponded exactly with the huauhtli as described by early writers. Moreover, its local name, "guaute," is only a variation of the Nahuatl *huauhtli*. Near Guadalajara Dr. Palmer found a paste made of this seed and sugar offered for sale in the form of strings of dumplings enveloped in corn husks, under the name of "suale," a corruption of the Nahuatl *tzoali*. He collected botanical specimens of the plant producing the seed, which proved to be an *Amaranthus*, evidently a white-seeded form of *A. paniculatus*. Although Dr. Palmer did not realize that he had rediscovered an important economic plant of the Aztecs, his botanical specimens together with his field notes, found by the writer in the U. S. National Herbarium, served to establish the identity of the sacred huauhtli. The possibility of cultivating this *Amaranthus* in suitable situations in the southwestern United States was suggested by the writer. Very closely allied plants, also producing white seeds, are cultivated as grain crops in India, Thibet, South America and Africa. Of the existence of this particular form in pre-Columbian America there can be no doubt. It remains to be determined whether or not the Asiatic and African plants were endemic in the countries where they are now cultivated, or were introduced there after the discovery of America. Mr. Safford's paper will appear in full in the Proceedings of the Ninth Congress of Americanists.

Fungus Fairy Rings in Eastern Colorado and Their Effect on Vegetation (with lantern): H. L. Shantz and R. L. Piemeisel. To be published by the U. S. Department of Agriculture.

Report on the Local Flora: A. S. Hitchcock.

W. E. Safford,
Corresponding Secretary

THE SOUTH DAKOTA ACADEMY OF SCIENCE

The second annual meeting of the South Dakota Academy of Science was held in Watertown, South Dakota, November 27 and 28. The following papers were read:

President's address, H. I. Jones.

"The Locust Outbreak in South Dakota in 1916," by H. C. Severin and Geo. Gilbertson.

"Water Culture," R. J. Gilmore.

"The Plankton of the James River," W. H. Griffeth.

"Soil Fertility in South Dakota," J. G. Hutton.

"A Study of Lipase," H. I. Jones.

"Aluminum Phenolate," A. N. Cook and G. N. Quam.

"The Chemistry of the Cell," J. M. Scott.

"Correlation in Corn," A. N. Hume.

"Notes on Sodium Cyanide," W. J. Sharwood.

The officers for 1916–17 will be:

President, A. N. Cook, Vermillion.
First Vice-president, A. N. Hume, Brookings.
Second Vice-president, L. G. Atherton, Madison.
Secretary, R. J. Gilmore, Huron.
Treasurer, H. Loomis, Brookings.

The next meeting will be held at Brookings in October, 1917.

R. J. Gilmore,
Secretary